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OF THE

Mineralogical Society

OF

GREAT BRITAIN & IRELAND

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1880.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Unitarian School-room, High Street, Swansea, August 27th, 1880.

A letter was read from the President regretting his inability to attend, nd enclosing the draft "Report of the Council," with sundry suggested mendations, which were adopted.

The following members having been proposed in accordance with the ules, were declared duly elected as ordinary members.

Dr. Jas. Hector, F.R.S., Director of the Geological Survey of New Zealand.
Mr. Thos. Stewart, of the Glasgow Corporation Water Works.
Mr. Jos. Gill, of Leadhills, Lanarkshire.
Rev. Geo. Gordon, L.L.D., Manse of Birnie, Elgin.

FIFTH ANNUAL GENERAL MEETING.

Held in the Unitarian School-room, High Street, Swansea, August 27th, 1880.

The voting papers previously issued to the members were examined, hen it appeared that the following members were elected as office-bearers or the ensuing year (1880-81.)

PRESIDENT.

Professor M. Forster Heddle, F.R.S.E.

VICE-PRESIDENTS.

Rev. Professor Haughton, F.R.S
Rev. Professor Bonney, F.R.S.

COUNCIL.

Professor A. H. Church, M.A.
Mr. T. W. Danby, F.G.S.
Mr. Jas. S. Merry, F.G.S.
Mr. I. F. Walker, F.G.S.

(In place of Messrs. T. Davies, T. M. Hall, M. H. Johnson, and R. xland, who retire by rotation.)

TREASURER.

Mr. R. P. Greg, F.G.S.

GENERAL SECRETARY.

Mr. J. H. Collins, F.G.S.

FOREIGN SECRETARY.

Dr. C. Le Neve Foster, F.G.S.

AUDITORS.

Mr. B. Kitto, F.G.S.
Mr. F. W. Rudler, F.G.S.

The following "Report of the Council" was adopted unanimously the members present:—

COUNCIL REPORT, 1880.

"The year that has just been completed, the fourth year of the Socie existence, finds it full of life and vigour, notwithstanding heavy numer losses which it has sustained in its membership during that period. Si the last annual meeting we have lost by death one corresponding mem and five ordinary members; and by withdrawal seven ordinary mem and two associates. The election during the year of a correspond member, twelve ordinary members, and two associates, leaves us exa the same in number as we were at our last meeting, viz:—

Corresponding Members,	24.
Ordinary Members,	... 124.
Associates, ...	24.
Total.	172.

The balance sheet issued with the 17th number of the Magazine, sh that the financial position of the society is good.

The 3rd volume of the Magazine, which has been completed since our annual meeting, is not less valuable than its predecessors. The societ again largely indebted to Dr. Heddle for a continuation of his exhaus work on the geognosy of Scotland, and for other interesting commun tions; we cannot but regret that he has had so few coadjutors. A v remarkable paper by Mr. J. Milne, of Yedo, should not however passed unnoticed.

To the unwearied editorial labours of its secretary the excellence of Magazine is largely due, and the Council have again the pleasure requesting Mr. Collins's acceptance of the honorarium of £20.

It is satisfactory to find that there is an increasing demand for Magazine outside the society. The net result of the sales last y amounted to £15 8s. and there is good reason to believe that this amo will next year be considerably exceeded."

The following alterations in the rules having been previously propo in accordance with rule 29, were agreed to.

Rule 8.—To add the words "and a sum equal to two-thirds of composition fees shall be invested in Consols."

Rule 30.—To add, "after which they shall be authorised to append following letters to their names:—

Corresponding Members.—C.M.S. (for "Corresponding Member of Mineralogical Society)."

Ordinary Members.—M.M.S. (for "Member of the Mineralogical Society)."

Associates.—A.M.S. (for "Associate of the Mineralogical Society.")

The following papers were read and discussed:—

"On the chemical formula of epidote," by M. l' Abbe Renard.

"On certain crystallized products formed in smelting operations," by Mr. W. Terrill, F.C.S., communicated by Mr. J. H. Collins.

"On the serpentine, hornblende, and schistose rocks of the Porthalla coast," by Mr. J. H. Collins.

Specimens in illustration of their papers were exhibited by Messrs. Terrill and Collins.

LOCAL MEETING.

Field Meeting at Skye, September, 1880.

A field meeting of the Members resident in the "Central District of Scotland" was called by the local Secretary, the Rev. W. W. Peyton; the little Bay of Talisker on the south-west coast of Skye being the locality chosen. A number of the members accordingly met at Sligican Inn, and upon the 17th Sept., along with some strangers who were resident at the inn, proceeded by coach to Talisker, which is some twelve miles distant.

The sandy little bay of Talisker is buttressed on both sides by mural precipices of great height; those upon the south rising in sheet after sheet of bedded trap, to the altitude of 867 feet. Over these vast walls of nearly vertical rock, torrents precipitate their waters from the very verge; that verge being in one spot the edge of a range of basaltic columns. Caught instantly by the wind which is sweeping upward from the extended face of rock, these waters become dishevelled and broken up into myriad drops, which, in the form of a misty veil, are waved hitherward and thitherward in perpetually changing folds; becoming for so long the sport of the winds, that it is only the drenched rocks beneath which vouch for their ultimate fall. Occasionally among the waving folds the sunbeams play, refracted into prismatic colours of rare brilliancy; producing a spectacle marvellous from the rarity of its occurrence, and conferring upon the locality a charm which enhances many times the interest which primarily attaches to it from the plenitude of its mineral wealth.

The party, conducted by the President, who had many years ago examined the locality, proceeded in the earlier part of the day along the *southern* shore, on account of there being on this side a risk of their being cut off and imprisoned by the tide.

To direct in some measure the researches of the party, Dr. Heddl gave a list of the minerals to be found here. This list included—

Analcime,—Stilbite,—Chabasite in pure blue crystals, and also of a colou approaching to *acadialite,—Mesolite* in downy acicular-crystals, and i feathery-like arrangements.

He also mentioned that the late Mr. James Russel here found the onl two specimens of *Epistilbite* which have yet been got in Britain ; one o these is now in the British Museum, the other in Dr. Heddle's own collec tion. The correctness of the locality is proved by the occurrence o acadialite in the matrix of the specimens. Russel also gave this as th locality from which he obtained a specimen which appears to be *scolezite* and this is also the locality given by him as that which yielded one o two bits of a finely-tinted pale-green *pectolite*, which is associated wit large and fine crystals of *apophyllite* in very short prisms. The deal Doran, however, assigns these to the east shore of Skye, near the so-call Prince Charles' Cave, and the near presence of liassic limestone points this as being the more probable locality.

With these hints to guide them, the party commenced their exploration and before rounding the southern horn of the bay, had found *stilbite* large spheres, resembling the sheafs of Faroe ; they also got *analcime.*

Immediately upon rounding the promontory, they found themselv upon the boulder-attrited pediment of two picturesque sea-stacks ; an here they found certain of the above recorded minerals in so great a plenty that the breaking them out of the rock consumed all the time which th advancing tide accorded to them.

The observation of chief moment was the finding of *Heulandite* by M Mackenzie, a gentleman who in a continental University had taken hig honours in his mineralogical examination. This Heulandite was in colou less and highly lustrous *b t s P* crystals : this is the second locality in whic it has been found in Skye ; common as is *stilbite, Heulandite* is one of th rarest Scotch zeolites.

In close proximity with this, *stilbite* was found in sheafy or club-hea aggregations of crystals of *a b p r*, and in crystals of the form *a b p.*

The observation of most interest, however, was the extraordinary exte to which certain beds of the rock were pervaded with amygdules, whic apparently sometimes constituted a third of its mass. In these cases th amygdules contained, in contact with the rock, the pale-blue and th flesh-coloured *Chabasite ;* immediately upon these were disposed rosett of a pale-blue colour, consisting of aggregations of small crystals with th form of *Thomsonite*, or of *faröelite.* The Presid nt was disposed to assig them to the former, from his having by analysis proved the occurrence

Thomsonite in igneous rocks of this age, which occur at the north end of the island. Superimposed upon these rosettes there lay beautifully delicate interwoven and matted arrangements of downy *mesolite*, or individual crystals of the same, of marvellous tenuity; these, which yielded with perfect elasticity to every breath of wind, shot from side to side of the cavity. *Analcime* in minute brilliant crystals, *n*, also frequently occurred here, for the most part in separate amygdules; a single crystal rarely presenting itself among those of *chabasite*.

Of the last named mineral it was observed that simple rhombohedra (and these were of the acadialite variety) very rarely occurred; twins of the same, somewhat less rarely; this variety being almost always in highly complex twins, which generally presented upwards the crossed face *a*. The blue variety was always in twins, but these were of less complex form. The flesh-coloured crystals were of very much more frequent occurrence, and the two shades never passed into one another.

This goes to support an observation which has been already recorded, that these varieties have a totally different composition. The forms in which the *acadialite* was found were, *p*, *pe*, *p t e*; twins *p t e s*, and the same with 12 small crystals of *p e* inserted upon the *e* planes. The form of the *blue* variety is *p e s* twin.

As regards this, the cliff-foot *south* of the bay, the extent of new information is confined to the discovery of *Heulandite*.

Hurried away by the advancing tide, the party made for the beach north of the Bay, and, in crossing the shores of the cove, observed that its singularly dark sands were composed almost entirely of comminuted dolerite, with about a fourth part of its bulk of clear granules of *olivine*.

Among the smoothed boulders which line the shore, before the rocks of the northern coast line are reached, there were found several which contain imbedded fairly-well developed lozenge-shaped crystals of *olivine* of the form *a d c*. Though these are not over a third of an inch in length, they are probably the best crystals yet noted from Scotland. Striated twins of *labradorite* of a pale-brown, and over an inch in length, rarely occur in a finer-grained rock, in others of these boulders.

Immediately upon reaching the fallen masses which lay upon the shore, the party found abundance of *analcime*, in both large and small crystals; —highly brilliant, colourless, and transparent; as also opaque and muddy-white, rarely bluish. No form other than *n* was seen. It was sometimes associated with superimposed crystals of stilbite *a b r*.

The interesting observation of the occurrence of *bitumen* was next made. It was first seen as a thick coating on the rock, surrounding an empty cavity which was lined with crystals of analcime. The rock in the

vicinity showed "tears" of the soft, tenaceous, and highly odouriferous substance, which had streamed over its surface for an inch or more. On breaking into the fresh rock, cavities,—sometimes half empty, sometimes full,—were found. In those which were only partially filled, the bitumen occurred with rounded or semi-globular forms, and its passage through the substance of the rock to the surface most directly exposed to the sun's rays, was shown by a dark stain.

It has been said that it was lodged in amygdules which were lined with crystals of analcime; minute filaments of *mesolite* sometimes passed through its substance also; but it occasionally occurred not in amygdules but filling rents in the substance of the rock; and sometimes apparently merely pervading the rock substance itself.

As lignite of liassic age, reduced frequently almost to mineral charcoal, has been found in many parts of Skye, imbedded in trap, there can be little doubt that the action of heat has distilled this bitumen out of the entombed exogenous plants.

Close to this bitumen much capillary mesolite occurs, traversing with its crystals the vacuous centre of analcime amygdules.

A gentleman who accompanied the party got a fine specimen of brown calcite in simple rhombs of the form *f*, these rhombs undoubtedly owe their colour to an impregnation of bitumen.

Mr. Peyton here made, in one block, a double find;—a far from rudely-formed crystal of very dark-green *labradorite*, 9 inches in length, by 5 in breadth. This, being made up of a multiplicity of crystals lying in every direction, went to pieces in the extraction. The small individual crystals are finely striated; it is called *labradorite* at present merely from association.

This assumption of a fairly well-pronounced simple form, by the aggregation of a multitude of small individuals which lie in polar discordance, is of very difficult explanation. It is to be seen in the orthoclase of Pitfechie in Aberdeenshire, and in several other minerals.

The substance which occurred in association with this giant crystal, was *lydian-stone*; it was in imbedded and rounded masses of a dark brownish-green colour; the masses were some inches in dimensions.

The tide did not permit the party to reach a spot where the fallen masses contain fine specimens of *chabasite*, and at which, many years ago, Mr. Dudgeon found probably the finest specimen of *analcime* which Scotland has yet afforded.

The following additions to the minerals of this locality were made:—*Olivine*, *labradorite*, *lydian-stone*, and *bitumen*, none of which had been chronicled by Dr. Heddle on his previous visit.

Retracing their steps, the party observed bands of *plynthite*, of some inches in thickness, zoning the cliff horizontally from bottom to top, at distances of about forty feet, and imparting to it an appearance which was altogether new to most of the members.

It was remarked that, as the specimens obtained were got almost solely from fallen blocks, and as falls were apparently not of altogether rare occurrence, the locality must be almost an exhaustless one. This is hardly a correct inference in either respect. The President did not see much change as regarded the number of fallen blocks since his last visit,—some five and twenty years before; while at the more northerly locality of the Storr, where at that time nearly every stone yielded a specimen, not a bit worth carrying away is now to be had,—the tourist love of *trophies* having swept it bare.

It is mentioned as a detriment to the tourist, and an instruction to the mineralogist, that good specimens are not to be obtained here without the employment of a hammer of at least 14 lbs. weight, while one of 7 lbs. will do twice the work.

List of Books Received from July 1st to September 28th, 1880.

From *Prof. Groth*, Strasburg.
Zeitschrift fur Krystallographie und Mineralogie. iv, 4, 5, 6.

From *Soc. Toscani di Scienze Naturali, Pisa.*
Procesi verbali, p.p. 53-64.

From *Soc. Mineralogique de France, Paris.*
Bull. III. 5.

From *Prof. Tschermak*, Vienna.
Min. und Pet. Mitt. III. 1, 2, 3, 1880.

From *Dr. C. Le Neve Foster, Llandudno.*
Reports of the chief inspectors of Mines for Victoria, 1874-5.
Reports of the Mining Surveyors and Registrars of Victoria, 1875 to March 1880.
Mineral Statistics of Victoria, 1875 to 1879.

From *Prof. Geo. J. Brush*, Newhaven.
On crystallized Danburite from Russell, St. Lawrence Co., New York, by G. J. Brush and E. S. Dana.

From *Prof. T. Rupert Jones*, F.R.S., Surrey.
On the practical advantages of geological knowledge by T. R. J.
On the Fossil Fuels of Italy, by the Chevalier W. Jervis,

From *B. J. Harrington*, B.A., Ph.D., Nova Scotia.
Notes on Chrome Garnet &c., by B. J. H.

From *Prof. Dana*, Newhaven.
American Journal of Science, July to September, 1880.

From *Reale Comitato Geologico*, Rome.
Bolletino, 5 to 8, 1880.

From *Professor G. Vom. Rath*, Bonn.
Mineralogische mittheilungen, by G.v.R.
Ueber den kentrolith, eine neue Mineral species, by A. Dam
and G. Vom Rath.

From *Professor F. J. Wiik*, Helsingfors.
Mineralanalyser utforda på Universitetets kemiska labaratoriu
&c., by F. J. W.

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X.—*On certain Crystallized products, formed in smelting operations.*

By W. Terrill, F.C.S.

Communicated by J. H. Collins.

CRYSTALS have often been accidentally produced in the various processes of smelting, having the form and composition, or nearly so, of natural minerals; and have been from time to time described in the scientific journals. Some few, however, which have come under my notice have not been, so far as I am aware, previously described; and as the importance to mineralogy of a due regard to the nature of such crystals, as well as the conditions under which they may have been formed, is beyond question, I avail myself of this opportunity to lay before the Mineralogical Society specimens of the few products to which I allude, and to explain the circumstances of their formation:—

Specimen No. 1 contains some dark green crystals of arseniate of copper, resembling in appearance native olivenite. Before the blowpipe on charcoal these crystals melted easily, then, with a sort of deflagration, gave off copious arsenical fumes incrusting the charcoal, and yielded a button of metallic copper. An analysis of carefully selected crystals gave 62 % CuO, and 38 % As_2O_3 with no water; except for the absence of water and the slight excess of CuO, this is the composition of olivenite. The excess of CuO may be due to adhering particles of the associated black

oxide. This specimen was formed in the bed of a reverberatory furnace used for smelting copper ores (ore furnace making coarse metal).*

Specimen No. 2 was found in the bottom of the same furnace, and formed under the same conditions as the first mentioned—It is crystalline black oxide of copper, CuO.

Specimen No. 3 is a tin-white alloy of copper and arsenic. In hollow spaces dendritic crystals may be seen, resembling the ordinary artificial crystals of pure copper; an analysis of this specimen gave 76·9 % copper 22 % Arsenic with traces of FeS etc, or nearly Cu_4As.

This alloy was a co-product of a charge yielding a copper regulus of 77 % Cu. (white metal); it separated completely from the regulus, which retained but the merest trace of arsenic.

Specimen No. 4 is the same product as the last mentioned, but having escaped from below the regulus, was oxidized whilst hot, and is covered with a layer of green arseniate of copper.

Specimen No. 5. "Coarse metal" cooled very slowly: in hollow cavities black octahedral crystals have formed which are strongly magnetic. They have only been analysed qualitatively, and they contain copper, iron and sulphur.

Specimen No. 6.—A piece of ordinary "white metal slag," which cooled and solidified upon a bed of "white metal." The surface which was in contact with the white metal below is beautifully crystalline in oblong patches, each patch being striated in two directions so as to form a cross. The striæ are so fine as to produce a remarkable iridescence.

No 6*a*. is the same slag showing the usual oblique pyramids.†

Specimen No. 7.—Thin lenticular crystals of a clear pale yellow color formed in the bed of a "test" used for cupelling argentiferous lead.

Chemical composition, pure oxide of lead. They were at first brilliantly transparent, but have become a little dull since.

Specimen No. 8.—Acicular crystals of molybdic acid, formed on the surface of a mass of melted regulus whilst cooling in the air, the regulus contained about 5 % molydenum, and the dross, consisting chiefly of these crystals, was found on the surface when cold.

*The brick work around was considerably cracked, and the vault below contained water for a long time previous to the destruction of the furnace, so that steam could easily permeate the bed.

† This slag is very similar to that described by Mr. Arnold in the *Min. Mag.* vol. III p. 114. J. H. C.

XI.—*On the Geognosy and Mineralogy of Scotland.*

By Professor Heddle.

SUTHERLAND.

EVERY writer has his moods. It may be thought that the present writer was cynical and severe in his remarks on the geognostic features of Caithness. With a view to remove any such impression, Dr. Macculloch's opinion of that country is quoted; specially in order that it may be used as a foil to what has to be said concerning the geognosy of Sutherland.

Hear then Macculloch. "On entering into Caithness all the pleasures of travelling are gone and past, for an uglier country from one end to the other would not easily be found. In the usual sweeping manner of those who love to generalise, like Humboldt, it is level, or, at least, not hilly, without trees, without enclosures, as black and as flat as Bagshot Heath; and flat as a pancake! Nature has provided no monuments, and has refused to be its poet. I saw a Caithness forest. It was of mixed wood, of about fifty or sixty years growth, and was precisely five feet two inches and a half high. The surface was so neatly cut and so compact and flat that I might have walked on it. I thought it must have required a large pair of shears; but the north wind and the east have long arms, and nature was the artist, while the dyke was the scale, and the limit—beyond which the winds had said it should not rise. Such a forest, potted, would have been a fortune to a Chinese.

"Liberty is a fine thing, and I do not know that I ever enjoyed it more than here, where I could see the horizon, and felt that I might walk and run and ride in any direction.

"The physiology of the country is quite unlike that of Scotland in general. A land scarcely elevated above the sea, a long surf on a smooth flat beach, great pools in the middle of close nibbled grass, sand, and the white tall steeple of Cannisbay like a pillar in the desert, not directing the people the way to heaven, but teaching mariners to shun the land.

"The headland of Dunnet Bay is an ugly square mass of red sandstone. Duncansby Head which rises to a considerable height, is red, square, and ugly.

"The lofty pass over the Ord becomes entertaining in descending into Sutherland. Hence, the country begins to look like what it actually is,—*a new creation.*"

All this monotony has been said to result from the nature of the rock which Caithness contains.

Five rocks, of a facies each differing from the others as much at le in the fashion of their sculpture, as it is conceivable that any stony boc could differ, are to be seen in the adjacent county—which Maccull declares to have the features of *a new creation*. Nor does this incl the whole;—these five lie on but one side of the country,—the weste passing to the eastern, two others appear; while igneous rocks of th very different natures still further diversify the whole.

There is no county in Britain which contains within it so many for tions; hence there is none which can lay claim to so many of the essent of geologic interest, and none in which there is *a priori* to be expected great an amount of diversified scenery.

Whatever extent of such expectations may have been indulged in, reality will here be found to exceed it. *Hills* of all fashions and fo and tints:—*Mountains* which rear their heads like waves which are cur aloft to break, and have been petrified in the poise:—*Rocks* of which contours are here graceful, there grand; here chaste, there grotesque; which ever differ each from the other:—*Water* disposed now in trenches, and slumbering between gloomy rifts, now sprinkled in innum able lakelets to the open eye of day, but each standing separate w strangely formed contours, like rain-drops reposing on a polished slab *Ocean* thrusting its tongues far in among the sombre hills in shade-lov meanderings; so tortuous, so lost among the land as to accomplish its b wards escape only at the cost of having become half freshened by the l embrace.

What a contrast to Caithness! Here nature has made her mighti effort as the grand and wonderful; there, exhausted, she slumbrou drew over her the Old Red blanket of actionless repose.

There are many counties which may rival this one in this effect or th grand combination:—there is none which for an instant can compare w with it in a diversity which ceases only when the ocean's verge is reach Here Old Scotland is in very truth, "the land of brown heath a shaggy wood, the land of the mountain and the flood;" and he if anywhere, we learn that she is indeed *Old* Scotland; not a recent created flat-featured parvenu, like others to which she has give foundation; these dark-green rocks were laid bare, as ocean's deser bed, ere ever the mountains were brought forth; they have resisted t billow's might during the many successive stages of the world's formati and have yielded the materials of its after growth.

If anyone could wander amidst the convoluted mazes of its hills wi out feeling his heart burning within him, it could only be from an ut

ant of sympathy with nature. The lungs play more freely, the stride ts longer, gravitation is an insignificant retardation, the big hammer's eight is scarce perceived; the whole man is improved in tone; even in e midst of nature's warfare, one feels altogether benignant,—so long at ast as she refrains from wrapping those grand hills in gloom.

Every geologist must be more or less of an artist; he is none the orse if he be a little of a poet also. And every artist should be more less of a geologist,—so far at least as to understand the nature of that hich he is depicting. And every true lover of scenery should get up his ology well, learning it in the class-room which has an azure dome, or s enjoyment is only that of the moment or of the memory; for the in- lect has otherwise nought to grasp; the heart may burn as the footsteps e turned hither or thither, but the cup of rational and reflective enjoy- ent can only be filled to the brim, while the silent record is being folded, the deeper lesson of the rocks being read,—the majestic mystery hich is half seen, whole felt.

"It is thus that geology when it quits the trammels of its disputes and theories, and puts aside its jargon and its trifling, illustrates even the rsuits of the artist. As far as landscape depends on forms, it will be nd that it is very often essentially regulated, as to its beauty or deformity well as its character, by the nature of the rocks of which a country nsists. And this is often true, even when the rocks are not visible; as e character of the surface, the outlines of the hills, the forms of the pres, and many other circumstances, depend on the geological nature and sposition of the rocks beneath. Nor is even the aspect of a cultivated untry, where all form is either originally absent, or obscured by vege- ion and improvement, so independent of the nature of the subjacent ks as might be imagined. So far from it, many districts have a charac- in their vegetating surface, if it may so be called, so marked, as not ly to indicate the nature of the rocks beneath, but to enable a practical e to decide where one kind terminates and another begins.

But where the rocks are exposed, the characters of the landscape, as se are affected by their differences, are still more marked; and it is n also more easy to trace the connection between the causes and the fects. In the district which has given rise to these remarks this is very spicuous; an entire and sudden change of character always occurring enever gneiss succeeds to sandstone, or the reverse.

I cannot part with this subject without suggesting how necessary the owledge of rocks is to the landscape painter; not only that he may pre- ve character and truth in his representations of mere rocks, but that he y avoid those incongruities of general aspect, which do not interfere th the truth of portraiture, or the consistency of style alone, but which

offend the eye. Nor is it only the eye of the geologist which is th offended; for in almost every representation of nature the uneducated a the unscientific detect, by something like instinct, faults and inconsistenc the nature of which they cannot explain; or rather perhaps they mer feel that something is wrong, while they know not what that someth is. When indeed landscape painters have been faultless in this particu it has arisen rather from what may be called the accident of their hav painted from nature carefully, and in the open air, than from corr general knowledge of the natural history or anatomy of their landsca That perfection in this department of landscape painting is rare, is a pr of the necessity which a landscape painter is under of knowing the anatom if I may again use such a term, of his rocks, as well as of his trees, plants, his shipping, his architecture, and his animals. I do not say th landscape painters ought to study the Huttonian theory, or learn to d tinguish between greenstone and basalt; but I must maintain that u they are familiar with the leading rocks of the earth and their charac istic differences, their works will be imperfect. To represent her earnes Nature must be known, "*iutus et in cute*;" and it is as vain to hope truth in this department of art, without knowledge, as to expect to p a horse or a man justly without being acquainted with their anatomy.

But I have done; satisfied, not with having given landscape painter wipe with my pen, but with reflecting, that if they will take these thi to heart, they will profit by them. All the arts and sciences materia aid each other; to a painter's necessary knowledge I know of no limi and even geology, I trust, may be rescued from some portion of the c tempt which the crowd of its miserable cultivators has brought on it, wi it shall have been raised to the dignity of a handmaid to the arts design."

The caustic writer of the above was a skilful surgeon, whose caus appeared only when the application was called for. In the belief that is called for here, no apology is offered for transcribing his words of wisdo

Looking at the extraordinary attempts to depict rocks which are to seen upon the walls of our Academys, the writer has often felt that, in much as five years of silent listening was a prominent feature of Pyt gorian instruction, so five years of wandering paintless and palletl among corrys and cliffs, should be a *sine qua non* before the landsc painter attempts to depict their forms and physiognomy.

These remarks find a place here most fittingly, because *here*, that is Sutherland, the student of Nature's lineaments will find them assum the most marked versatility of expression; and here, as it is well in t as in all things to begin at the very beginning, the artist will be able study the first foundation-stones of all.

In the midst of that diversity, moreover, he may imbibe of that inner essence of poetic feeling, without some trace of which, transferred to his portraiture, no painting can image forth nature's face at all. Unless the meaning of nature's imagery be understood, he had best go back to sign-boards and portraits.

Sutherland is a school-room teeming with studies for both painter and poet. The almost endless diversity of its scenery gives amplest scope for the unfolding of the sympathy which exists between the inner being of man, and the outer face of nature, and the idealism of the expression of its features.

The ghastly cheek of Arkle is that of one who knows his next step—the grave. The terrific peak of Coul Beg was surely so *cast* as a conductor to break that livid vapour, and draw the lightning's flash.

The lurid gloom which hangs under the lowering crests of Foinaven, and rolls steaming up that grim trench of Dionard, must surely only lead to the "cold swellings of the dark valley's waters." The tremendous gash, cinctured by Craig Riavach's cliffs, which trends visibly to *nowhere*, can scarce be ought else than one of the Gates of Hades.

Suilven "heaves high his summit bare," the perfect model of a light-house,—for a "Sugar loaf" is never made of *brown* sugar.

Stack Polly is a porcupine in a condition of extreme irascibility; and Soul More, quietly reposing upon her back, teaches Jura a lesson in deflicting lines of female loveliness.

It is a most impressive scene to stand on the lonely moor of Lewis, and look eastward across the Minch at those diverse-tinted and wierd mountains of Sutherland. They are wierd and wondrous from afar, but it requires no distance to lend enchantment here. They are wierd and wonderful when they are melting away in blue haze; they are weird and wonderful at every forward surge of the vessel as we approach them—there is no need to place oneself in this position or in that, they are graceful and grand from every side; and they are most wierd and wonderful of all when, twining among their splintered pinnacles, we gaze beneath us to a gulf of mist, and have come to learn that that gulf was once filled with solid stone, and that the great mass up whose slopes we lately toiled, is but a crumbling relic of a vastly greater mass,—one indeed which once stretched both hitherward and thitherward for well-nigh a hundred miles.

The impression conveyed by their aspect from the Lewis is that we are contemplating a sepulchre;—the strip of water lies before us like the wall of a churchyard;—it is just as if we were looking over the wall of a churchyard into a burial-place of the dead. These diverse-tinted cones stand erect like tombstones from a dead level, for all the lower land is sunk. They function as tombstones moreover, for nought but themselves

is left to vouch for the previous existence, and tell the life-history of tha which they represent. Nature sometimes *raises* a tombstone, rearing or aloft by a convulsive effort. In Scotland, in the old days, the rule seeme to be to do everything by *digging downward*. And so these great mono liths were not set up, but the earth around was cut away from them, afte the manner of the Sphinx, and not a few of the heirogliphics which an to tell their story were scratched upon them in the digging.

The fashion of the heirogliphics moreover is very different upon each— we can see that as we are getting across the wall; in the deciphering w are helped if we regard them from all distances, and it is not good to com too near. They run in gently waving bands vertically up the face of th dark tombstone; when we get to the back of it we find them comin equally directly down it; while if we climb to the top, we discover th two sets of lines to be continuous, for they strike right across the summi That great red mass is barred from side to side, and from base to its acu nated peak with deeply chiselled horizontal streaks, now bold, now fai now close, now far apart. These are not written upon its face alone, b pass in almost level course across its sides to meet upon the back,—ea with the self-same stroke again.

On that opposing shaft, again, the writing of the finger is more fai because the pale stone is very hard, and the writer sloped the lines alwa to one side of the pillar.

Three different styles of writing are palpable to us, before we are clo enough to study the characters themselves. This study requires a corre reading of the legend, and a no less correct interpretation. There h been not a little differing as to the first, and squabbling as to the secon there has been even but little agreement as to the nature of the sto themselves; and then came the usual result,—individuals carrying b hammers got into the burial-place, and made use of the same in feats sacriligious muscularity.

It is not, however, the whole expanse of Sutherland, which possess this plenitude of scenic wealth: the tetter of Caithness' hideousness h crept across the border and far into its centre To anyone who wishes get himself into good condition for appreciating scenery, we would r commend a walk from Arscaig, on the south shore of Loch Shin, in th direction of Loch Ailsh. There are here, certainly, no grand combinatio of serrated peak, with finely-contoured slope, with gloomy tarn, or brigh green sea-loch with golden edging:—of bosky dell with glancing riv glinting through birken tracery:—or of ocean's foam, with verdant is and beetling cliff. It may be said of Sutherland *scenically* what has be said of Fife *agriculturally*, that it is "a serge mantle with a gold fringe;" and here we are in the midst of the serge. Roll after roll

shapeless humps of heath-clad rock—at least we suppose it to be rock, for it is so enveloped that the hammer's occupation is gone. The very heather is featureless and meaningless :—the short-cropped ling, with scarce a single bell. The ear does not listen to even the companionship of a raven's croak. The pained eye turns in vain for relief, and turning falls, almost with a shudder, upon the vast, Acheron-looking, Loch Shin ;—a great gutter, whose waters resemble flat-porter in shade, and molten-lead in sunshine. Sentinelled, and even they stand far off in repugnance, by the only two ugly hills in Sutherland,—Ben Klibrick and Ben Hee,—it resembles a great trunk of a mighty river which has been dammed off at both ends, and left to stagnate ;—an incubus upon nature,—a huge smear upon the face of beauty.

This central district of Sutherland, may be left to the coleopterist, as the only species of naturalist who never lifts his eyes from the ground ; the botanist, mineralogist, and artist alike would flee from it, and make for the golden fringe. Bursting southward, he would light upon the greenery of Rosehall, and the sylvan softness of the lower Oikel ; northward, he there would pivot among the beauties of the hundred-pictured Tongue, as oft as he could snatch his gaze from the queenly Loyal : or westward, traversing the great gash of the mountains, he would pass between the grand portals of Arkle and of Stack, and enter upon that weird tract, which, stretching from Applecross to Cape Rath, appears to have been the workshop of the Titans, and which presents so marked a contrast to the dreadness and dreariness which he has left behind, that he cannot but speculate upon, and search into the causes of so strange and so stupendous a dissimilarity.

By almost all who have written upon the geognosy of Sutherland has the wondrous diversity and the striking features of its scenery been noticed, although no one of the writers has gone very far in attempting to show how it comes that this diversity has been so concentrated in space.

Cunningham says that in the county "every variety of alpine and cliff scenery may be found," and that "it affords, in its undisturbed solitudes, all which constitutes the sublime in nature." Without going so far as to say that every variety of *cliff* scenery occurs in it, the correctness of the statement as regards its *mountains* may be maintained, and it is the ever-varying features which these present, which has impressed the most.

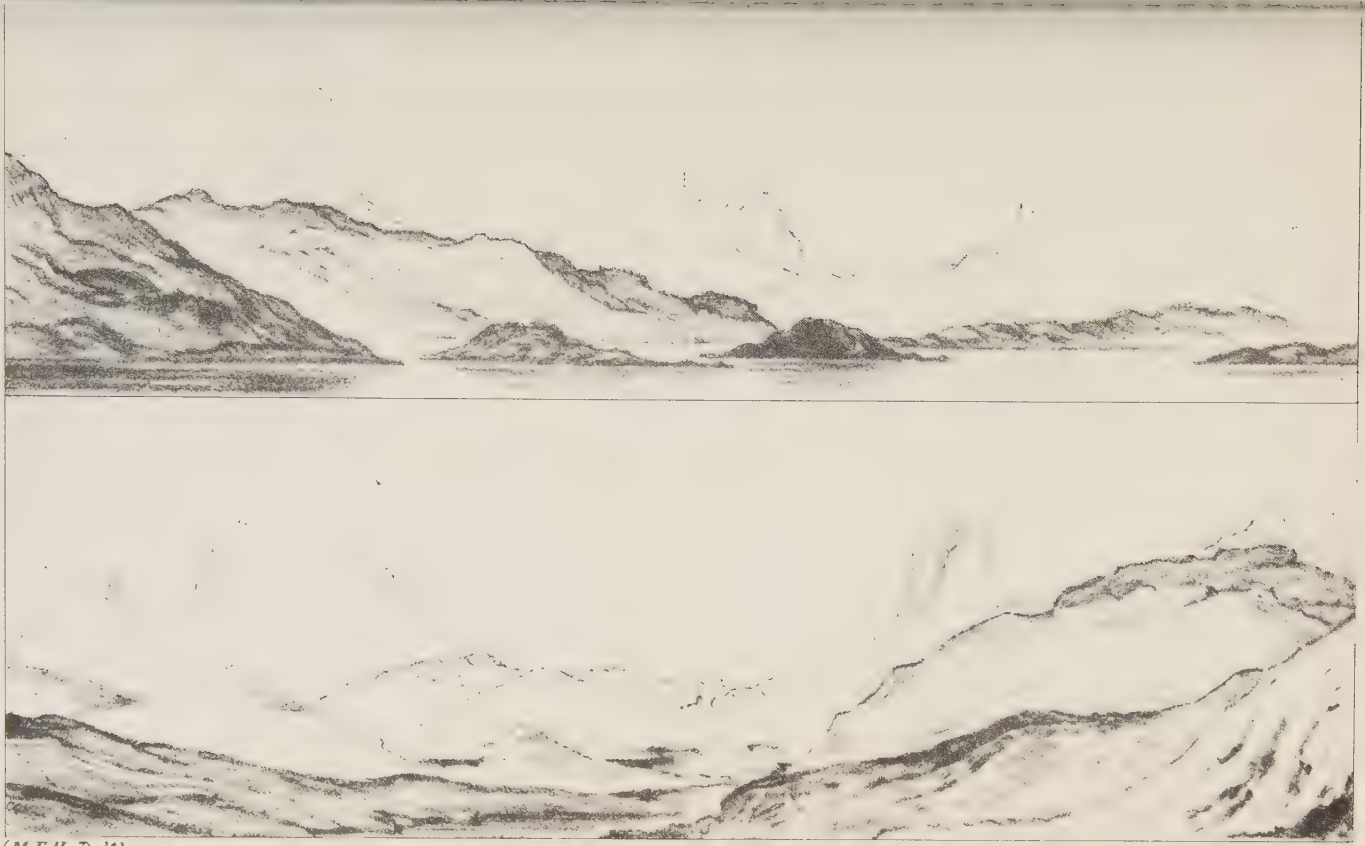
Nicol remarks—"The mountains, rising abruptly from the great table land of lower hills in smooth-rounded cones, spiry peaks, or long serrated ridges, their hoary summits shining in the sun like new-fallen snow, and sending down streams of rugged fragments to the deep sea-lochs that, running far up into the interior, wash their bases, present scenes of wild

and varied grandeur unknown in other parts of the island. Nor does closer examination lessen the wonder with which we regard these mou tains. They are then found to consist, not of granite or igneous rock nor of the older so-called primary strata, crushed up and broken by som great convulsion, as their singular outlines might have led us to expec but of stratified rocks of no great hardness, lying almost horizontally thin even beds, and moulded into these strange forms by the slow agenc of natural causes."

Speaking of but one type of these alone, Hugh Miller describes the thus :—"Rising over a basement of rugged gneiss-hills that present th appearance of a dark tumbling sea, we descry a line of stupendous py mids from 2000 to 3000 feet in height, which, though several mil distant in the back ground, dwarf by their great size the nearer eminenc into the mere protuberances of an uneven plain. Their mural charac has the effect of adding to their apparent magnitude. Almost devoid vegetation, we see them barred by the line of the nearly horizontal stra as edifices of man's erection are barred by their courses of dressed sto Their colours, too, lend to the illusion. Of a deep red hue, which in t light of the setting sun brightens into a glowing purple, they contrast strongly with the cold grey stone of the gneiss tract beneath, as a warm coloured building contrasts with the earth-tinted street or roadway ov which it rises."

While again, even while confining himself to a small cluster whic circles Loch Inver to the eastward, Dr. Macculloch has an ample field fo his grotesqueness.—"Round about, there are four mountains, which see as if they had tumbled down from the clouds; having nothing to do wit the country or each other, either in shape, materials, position or charact and which look very much as if they were wondering how they got there Which of them all is the most rocky and useless, is probably known t to the sheep; human organs distinguish little but stone: black precipice when the storm and rain are drifting by, and when the sun shines, coll bright summits that seem to rival the snow.

"Suil Veinn loses no part of its strangely incongruous character on a near approach. It remains as lofty, as independent, and as much like a sugar loaf (really, not metaphorically) when at its foot as when far off at sea In one respect it gains, or rather the spectator does, by a more intimat acquaintance. It might have been covered with grass, to the imagination but the eye sees and the hand feels that it is rock, above, below, and round about. The narrow front, that which possesses the conical outline, has the air of a precipice, although not rigidly so; since it consist of a series of rocky cliffs piled in terraced succession above each other the grassy surfaces of which being invisible from beneath, the whole seem



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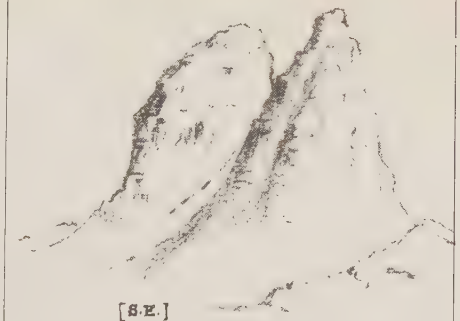

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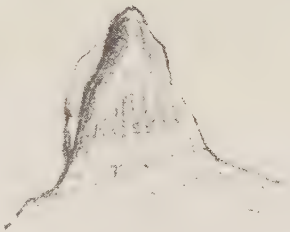

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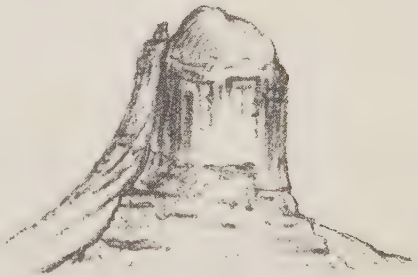

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M.E.H. Delt.

(W.IAGO. Fec.t)

ne rude and broken cliff, rising suddenly and abruptly from the irregular able land below, to the height of a thousand feet. The effect of a moun- ain thus seen, is always striking; because, towering aloft into the sky, it ills the eye and the imagination. Here, it is doubly impressive, from the vide and open range around, in the midst of which this gigantic mass tands alone and unrivalled—a solitary and enormous beacon, rising to the louds from the far-extended ocean-like waste of rocks and rudeness.

The conical appearance of Suil Veinn vanishes on a side view. Thus een, it displays a prolonged ridge with an irregular summit: but the ides all around are precipitous, like the western extremity; and, at the ast end, it terminates in a similar manner; looking wide over an open ocky country, and thus preserving its independence in every part. The ateral outline is varied and graceful, the whole mountain, in every direc- ion, presenting an object no less picturesque than it is uncommon and triking in effect." *(See Plates, Gables and Flanks of Suilven.)*

In these descriptions we find one writer startled by the close association f such distinctive forms as "smooth rounded cones, spiry peaks, and long errated ridges," which alike "rise abruptly from a great table-land." 'hese forms being stated by him to be *quite unusual to the material* 'hich has been fashioned into them; while the agent which has accom- lished a work apparently calling for violent effort—"crushing, breaking, nd convulsion,"—declares itself as the "slow agency of natural causes."

Another writer gazes with wonder upon a superior quiescence which 'as unaffected by an inferior turmoil,—a quiescence of deposition so 1arked that he is carried back to his memories of "dressed courses," ectilinear streets and roadways, and the molecular regularity of "edifices f man's erection;"—"horizontally barred pyramids of mural character" 'hich are based on "rugged hills which present the appearance of a dark umbling sea."

The last writer makes the assertion that these strange masses have *nothing to do* with the country or with each other, either in shape, 1aterial, position, or character;" while he adds that they "look very 1uch as if they were wondering how they got there."

It is quite possible that *they* know more about that than many of those 'ho have undertaken to tell it us; and it might be as shrewd a surmise to ay that they look as if they were wondering how they were *left* there.

The three geologists from whom the above quotations have been made, ad, we make bold to say, walked more over Scotland than any three men ving,—their remarks show clearly enough that *they* wondered how these ills *got there*, and they may therefore be worthy of the regard of others 'ho may not have seen so much, and thought so much, and taught so 1uch as James Nicol, Hugh Miller, and John Macculloch.

It certainly would seem to be very specially the function of the geo- gist or at least of the petrologist to give the earliest lessons in the stu of hill and rock sculpture; and certain we are that if such a function we accorded to him, he would select Sutherland as his class-room.

Here he would find the greatest *variety of material* for the operatic of nature's chiscllings, and here he would be presented with the m ample series of illustrations of *diverse result*. From among these, witho difficulty, might he select well-defined types of the various for of Scotland's hills, which he would broadly classify into her *domes*, h *peaks*, her *ridges*, and her *cliff-fringed slopes*. He would learn with whi of these her *butresses*, her *aiguilles*, her *seridans*, and her *scalps* were m closely associated; be able to perceive how it comes that here a roc mass lies supine in a massiveness which appears capable of defying ev the earthquake throw; while there, "worn and wasted to the bones," splintered pinnacles of precarious poise, its yearly topplings are batter its pediments into shifting sand.

How it comes that upon this hill the mantling sward seems lovingly shield its rock from the gnawing tooth of the atmosphere; while in t hollow, it palpably is living upon that which it embraces, and eating i it with most insatiate craving.

Perchance he would here, though not so much as in other parts Scotland, be impressed forcibly with the empty assertiveness, the *pret tion* of most of the so-called great hills; especially of those of the rid and spur type; see how little there is in them after all; what m skeletons they are—bared of every lineament of life; and as he passed, balancing himself rope-dancer fashion, along their back-bone ridges, w loose stone slopes, hardly at the angle of rest, which start from his ve feet on either hand,—smile at the vanity of the patriotic poet who spea of the "*everlasting*"—the "*unchanging* hills."

But not in one county, or on one formation, or at one side of a countr can its hill-forms, and their sculpture be learnt;—this can only be a tained to—the power of grasping the salient features of any one, can on come from an ever-widening fellowship with all; from winding amo their slopes, and scrambling among their corries, till they become almo unto him as familiar friends—ready to picture themselves upon the reti of his memory with easily recognisable sharpness, from every point of vie

A very singular fact, but perchance an easily to be explained one, if w only had the perfectly-fitting key, would then arrest the attention. Th is, that very much the greater number of the ridged-hills of Scotla stretch their length from W.N.W. to E.S.E., while their steeper slopes their cliffs, as the case may be, face the N.E., more or less directly.

From certain geological facts to be alluded to below, this does not app

Sutherland to so full an extent as to Scotland generally,—yet it will be en that—if we except cliff-faces which front the west (and this exception lds in many districts) on account of the rock-escarpments demanding ch a frontage,—it does obtain even there.

This singular fact will be fully stated and considered in treating of e Counties in which it is best seen.

The close concentration in space, of Sutherland's *many-faced* scenery is to be accounted for, first, as regards its great diversity in form, and condly, as concerns its colouration.

In form, it is the resultant of the meeting, almost along one line, of ree, it might almost be said of four great formations:—of the rock-asses which form these being acted upon by the agencies of degradation very diverse manners:—and of that line having been rent and dislocated r a great longitudinal fault,—by a system of nearly parallel transverse ults, and also by occasional divergent rents, which let-in wedge-shaped gments, in positions which produce extremely contrasted effects ong the diverse-tinted rocks. So dislocated, rent, and fragmentary a ries of rocks, afforded on account of their opened joints, a comparatively ble resistence to the assaults of the many agencies, each of which, by its ting tooth is potent as a fashioner of the surface-contour of the land. ssaults of such agencies as the battering of waves, and the scour of hirling tides; of toppling blasts, of the rending expansion of freezing ter, of abrading and polishing sand-scourgings, of cannon-cutting vers, of plowing and rounding ice, of the loosening and gravitating nsport of soaking rains,—of all the agencies which hurry the dry land to the great sink of the Ocean,—even as they do at present.

There is abundant evidence that all acted then as now,—then as now ving upon the frontlets of each rock-mass a tracery of decay, character-ic and diverse as the diversity in substance and in colour of the rock terial themselves.

The hills differ also in their forms *on account of the amount of action on each having necessarily been very unequal*; for the most ancient of ese formations has been modelled and remodelled many times, till it is rchance but its wasted pediments which, in low rounded hummocks, ne remain; while, of the more recent, the massive thickness has in many ces been but little cut in upon, and still reposes in long stretches of broken solidity.

The district to which the above applies has an average width of ten les, measured from the western shore; and the same general feature scenery extends as far south as Torridon, though hardly to Applecross. The rock-pabulum out of which this diverse scenery has been sculptured highly complex.

Commencing at the sea-margin, and extending as a pediment beneat all the other rocks, almost to the eastern verge of the district name there is found the wasted remains of what was formerly, unquestionabl a once great land. At that eastern verge it either sinks beneath th ocean,—is entirely swaddled and concealed by the overlying rocks,—or cut off from the younger eastern formation by the great fault.

Taking the sea level as its limiting cincture, and stripping from off it surface the overlying masses which now conceal it, its geographical cha presents us with a number of low islets clustering closely, and a sing range of peaked hills. These alike stretch from N.E. to S.W; and th present the counter-part of the extended and dissevered tract, which under the name of The Long Island, lies parallel to them westward the Minch. A geographical chart of this Eastern Hebrida with its rang of great hills is given. Its eastern coast-line is, at its south-eastern ex tremity, somewhat problematical.

Formed of the same rock, with identical strike of rock-layer, th *Eastern* and *Western Hebridia* unquestionably present themselves as t remnants of a country, the great thickness of whose deposits, as evinc by the almost unvarying continuance of one dip, entitled it almost to claim to the dignity of *Continent*.

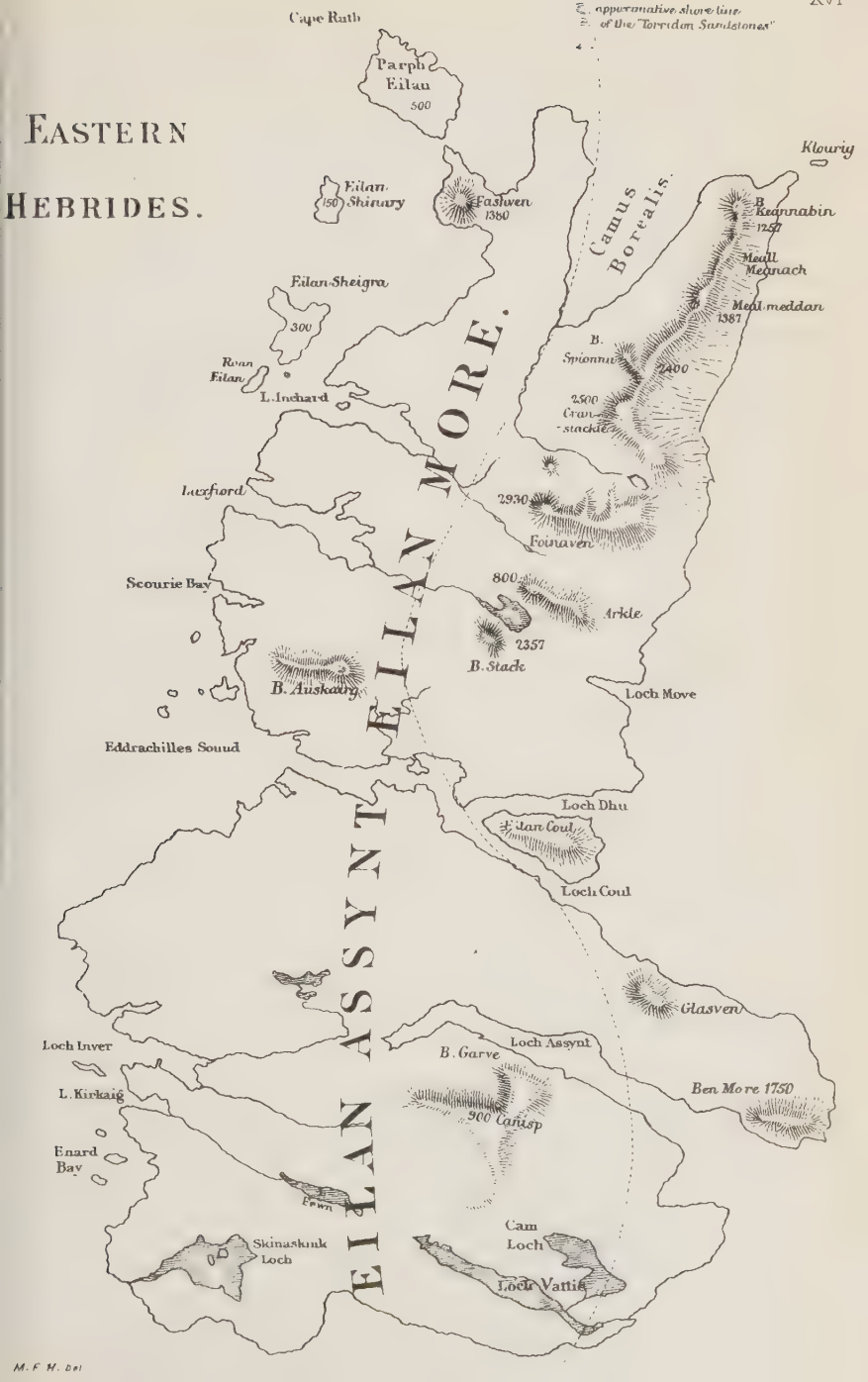
Out of the sorely-wasted remnants of this ancient land, probably wh sinking beneath the waters,—rung-out to give place to the new,—t chisels which sculptured the features of the old-earth crust, trenched a deep north and south valley, now termed the Minch. This, forthwit submerged, received into its quiet and many-shored waters, layer after lay of comminuted debris, which, consolidated by accumulation of pressur and agglutinated by metamorphic change, presented themselves upo the returning cycle of elevation, as the many-bedded trough of th Conglomerates. These, from their great dominance in that district, hav fittingly received the name of *Torridon standstones*.

It has been said that the vast thickness of strata of the basement rock vouches for its great extent as a formation. A common profundity o position and similiarity of structure has induced speculative geologists t link it, under the Atlantic floor, with rocks of the Western World, an correlate it with the *Laurentian* of that Continent. It is a more temperat speculation which links it with the Long Island, and rests satisfied wit asserting that it is the oldest rock in Britain, and probably in Europe.

The general character of its scenery is most peculiar. Looked at from distance, its appearance is simply repulsive,—a low table-land formed of in significant hummocks of bared and barren rock.* Considered in detail, i

* This feature will be seen in the sketch of "The flank of Suilven," and also in th foreground of *one*—the upper—of the sketches of "The hills which look as if they ha tumbled out of the clouds." The foreground of the lower, with its gently sweepin curves, consists of the "Upper gneiss."

EASTERN HEBRIDES.



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esents itself as a labyrinth of beauty. Viewed from an elevation and at a stance of several miles, the myriad lakelets which stud its surface confer on it the appearance of a swamped bog seem from the top of a hill. irly judged, as with ever-doubling course we wander amidst the mazes its lakelets and boskey knolls, we find each one to be an exquisite cture of craggy outline and winding shore, of rockey islet, and rich own water-tints, and boulder-beach confusion;—of never-ceasing anges of form, and of endless surprises.

It all depends upon time being given to do it justice. Hugh Miller uld not see its beauty in presence of the wondrous hills which tower ove it; though he happily compares it to "a dark tumbling sea."

Dr. Macculloch, who was as just in his criticisms of scenery as Ruskin grand, writes of it: "The surrounding country is a melancholy xture of lakes, rocks, and bays; the general effect of which is as agreeable as can be well imagined. And yet this air of desolation is be sought for in the sky rather than on the earth; it is all the effect climate. When we fairly examine these little lakes, and all those nute details of rock, and bank, and stream, there is not one that is not autiful, or which at least does not contain the fundamentals of beauty. ere there trees to dispose of as we pleased, I know not of such a llection of little paradises as might be made out of this very country. ture, I know not why, seems to have reserved her chief beauties for ces where she is quite sure they can never be improved or enjoyed."

A walk of three miles—which will take two hours to accomplish—due st of Rhiconich in the direction of Loch Garbat More and Garbat Beg, a typical one; it will leave upon the pedestrian (if that can be fairly lled pedestrianism in which jumping bears to stepping the ratio of 2 to) the impression that in this "melancholy mixture of lakes, rocks, and ys" he has somehow been surfeited with beauty.* The absence of es, which Macculloch deplores, is not morover, invariable. There are, alities where the rounded swellings of this so called table-land, are plified into hills of considerable altitude; as in the case of Craig Tolly, the lower end of Loch Maree, and the grandly opposing pine-clad ntlet of Ben Arrihaar. Here the scenery assumes much of the features ich prevail at the Trossachs, being however incomparably grander, and

* At Loch Garbat More the scenery is very grand,—the angling is however poor. ch Garbat Beg is somewhat tame, scenically, but the angling is super-excellent. In Visitors' Book at the Inn of Rhiconich there has been written:

Loch Garbat More, I beg you see.
Artist.
Loch Garbat Beg is *more* to me.
Angler.

nose who are "*Heelan*" enough to be able to translate *more* and *beg* will see the point.

less confined. The birken-clad slopes of Stack, also, are altogether perfect.

Throughout the whole of this "table land" the same feature of rounded knoll-like hummocks obtains; hummocks which in their bared surfaces exhibit the denuded edges of high-tilted strata, while their curvilinear outlines vouch for the fact that, whatever combination of agencies had effected the enormous amount of denudation which such an extent of shorn-off outcrop vouches for, polishing ice had been the agent which ultimately had conferred upon them their characteristic forms.

That the ice sheet which had effected this was of no great thickness is disclosed by the multiplicity and abruptness of the curvatures; there palpably had not been weight sufficient to grind all down to anything of a uniform level; rending and regelation of the sheet must have been incessant.

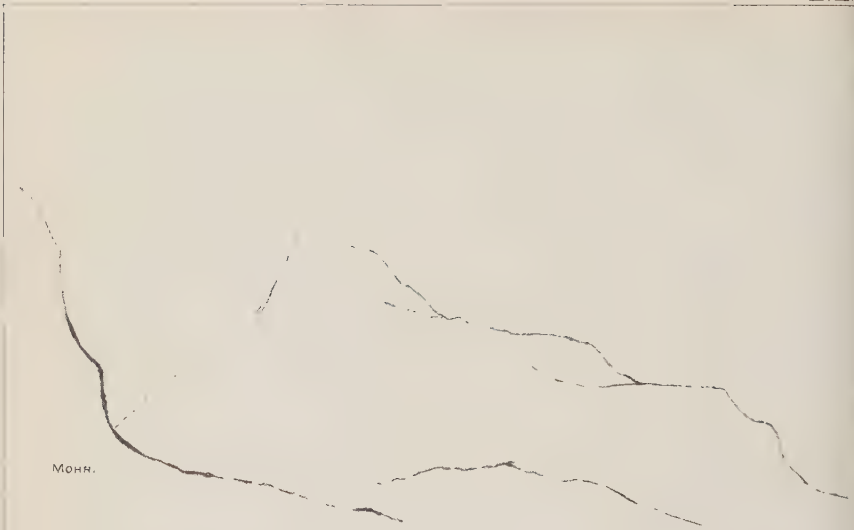
So much for the *subœrial* scenery of this wasted formation;—a troubled sea of heaving but *not curling* billows;—sombre coloured, lake besprinkled, ice worn;—weather-wasted when it lifted its head above the waters; swaddled in shingles, and over and above these swathed in sands and silts, when it was depressed beneath them. Re-elevated and again depressed, but with each subœrial exposure subject again and yet again to the many biting teeth of atmospheric gnawings, as each super-incumbent and protecting belt was cut through, in that unceasing process which abstracts from the pre-existent, materials for the construction of the new.

But the formation has a *subterranean* scenery, as well as a subœrial.

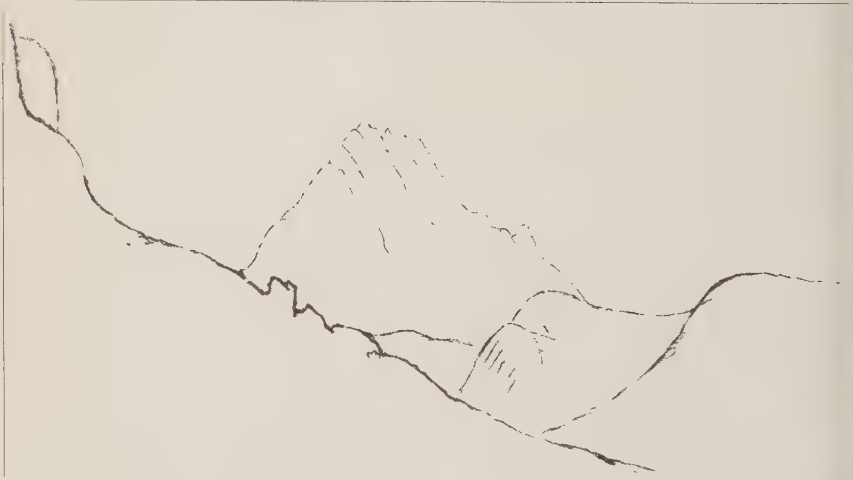
Murchison, while denying that the formation anywhere showed itself to the eastward of the over-lying quartzite, admitted that it might in some undiscovered locality be "brought up,"—that is, *eruptively* brought up—even far inland to the east.

But it *is* "up"; that is, it is *surface-exposed* to the east of the quartzite without having been "brought up." "Up" even in cliffs of over 1000 feet in height, and *so* up because *there* it was never ground down; remaining still as a range of lofty hills, the highest peaks of all the old islands of either Eastern or Western Hebridia.

There they remain, because they were swaddled up during one of the dips which Old Scotland took beneath the waves; and they are seen only where the swaddlings have been much thinned off, or altogether removed. A dome-shaped eminence which now forms the main bulk of Fashven protruded in the N.W.; and a range of peaked summits extended from Kean-na-bin to Ben Stack in the east, when the formation stood with bare head beneath the aerial dome. Of this range what is now the western peak of Foinaven forms at present the culminating point; this has an attitude of 2952 feet; but, as two outliers of quartzite of about 25 feet in



BEN GRIAM BEG. OLD RED SANDSTONE.



BEN STACK. HEBRIDIAN GNEISS.

M.F.H Del

hickness repose upon the highest point, 2930 feet (Keanngarbh) is now highest elevated point of Hebridia which remains.*

Of the features of this alpine range of the old continent, the thinness of ie cover which inwrapps it, permits it to be disclosed that the summits ere of peaked form. From one indeed,—Ben Stack, of which an out-ne sketch is given,—the cover has been totally denuded, at least at its ghest or western summit; and it towers in isolated pre-eminence over e plain,—a haystack-gabled hill.

We may not do more than suggest that even this old formation had its .E. cliffs; for, though it is probable that great part of the stupendous ecipice which, from the N.E. front of Keanngarbh, depends over Corry-ual, had been formed in that ancient day, and had posteriorly been eathed in the more recent deposits, still it is possible that it may ve been partly cut-out by more recent denudation.

It is a strange history which this mountain range of Eastern Hebridia ds in unfolding. An almost continuous line of peaks dominates nigh 00 feet above a table-land; peak and table-land alike being carved out the high-tilted edges of the strata; and, as the range of hills runs ross the strike, these peaks owe their existence to no folding of the ust; and there is on neither side of the range the smallest evidence of al fault,—of either upheaval or depression.

The table land must have been formed by the cutting away of the rocke stward of the range.

What cut it? and when was it cut? It has been already shown that was its *most recent* cutting tool,—ice which simultaneously had cut-in on the more recent of the local rocks;—but it was also pointed out that e hummocky feature of the plateaux indicates but a *small thickness* ice. This *recent* cutting then could not have effected the great and neral abrasion; and that it did not do so, but that the great table-land was med when Hebridia stood *a formation by itself*, is proved by the fact at the succeeding formation *lies upon*, and rears its sculptured hills *from t levelled but gently undulating table-land.*

What then had shorn away the land, so as to form the great flat ateaux?

Not atmospheric agencies,—the rock everywhere still shows itself as a st unalterable one. Not breaching waves,—sea cliffs are nowhere visible

* Our fellow member, Mr. Colin Phillip, tells me that, from the altitude which he ained upon its western slopes, he was able to see that the summit of The Maiden,—a l which lies north of Slioch, consisted apparently of the "old gneiss," and was either t rock or the "igneous rock" of the great fault,—(afterwards to be noticed).

f this be so,—and I have great confidence in his experienced eye—then, as the iden is about the height of Slioch, and certainly over 3200 feet, *it* must be the highest k of the old gneiss. Cleesham, in Harris is, by the author's measurement, 2,785 feet.

upon the flanks of the range, which are of curvilinear outline. Not the scour of waters; no river trenches, with sloping banks which eat back into the land, are anywhere to be seen,—the plain is a great flat, and the lake-hollows are all primarily occasioned by *recent faults*,—as will be afterwards shown.

Ice, alone of nature's agencies, remains to accomplish it; ice, engendered among the lofty eastern peaks. The presumptive evidence is strong; actual evidence is in several localities available. Upon precisely the same grounds that we assign the rounded forms and curvilinear outlines of the rocks in the throat of a pent-up mountain-gorge to the grinding passage of ice, are we entitled to hold that ice cut away *at least the surface* of the low land from which the great landmark hills of the Torridon Conglomerates rear their banded cliffs. For beneath the pediment-strata of these towering masses do the sweep of curvilinear outlines and broadly-rounded forms pass.

It is true that the sweep of these is more gentle and less abrupt than that of the more recent graving, but the character is the same. Nor is the very lowest land alone which would appear to have thus been subject to the sway of this old ice; for one of the localities where *ice-sign* is best seen is upon the outlying hill of Fashven; where, *upon every side* upon which the junctions can be seen, sweeps, which would give the low rock a dome-like form, seem to glide under the mantling-cap of Conglomerate.

The same is to be observed upon the north side of the gneissic islet at Sandwood,—east of the lighthouse at Cape Wrath,—the south-eastern foot of Suilven,—the head of Loch Veyatie,—and, in a most suggestive form, to be afterwards considered, at what I will call the *south terrace* of Arkle.*

This range of hills then, among whose peaks was cradled the *nevé* of an ice-sheet which swept westward, lay some ten miles from the present western shore. There is evidence to be seen upon the western shore of Loch Erribol, that the old land did not extend much further eastward, unless it so extended at a great depth. In this direction it may, for purposes of a newer formation, have been all used up; but close to this the great fault comes in, and no portion of the old formation has been found as yet (even "*brought up*") to the east of that. Be this as it may, the summits of these dark-tinted hills, with grizzly cliffs, vertically seamed by the junction-lines of the contact-beds, protrude themselves, in conse-

* Since the above was in print, I have read a report of Professor Ramsay's address to The British Association, on the occasion of its Meeting at Swansea. In this he says —"I received a letter from Professor Geikie, in which he informed me that he had discovered mammillated moutonnée surfaces of Laurentian rocks, passing underneath the Cambrian Sandstones of the north-west of Scotland, at intervals, all the way from Cape Wrath to Loch Torridon, a distance of about 90 miles."

ience of the action of degradation, through the thinned-off beds of an erlying rock. One which, in the case of the loftiest summit, is as markable for the lightness of its tint, as is the protruding mass for its mbre tone.

This great hill of Foinaven, though seemingly of quartzite, is in its bulk rmed of the old gneiss;—thinly in its western, thickly in its eastern portions antled by quartz rock. Formed of a narrow west and east ridge, which tends for some miles, it to the northward throws out several spurs. ver both slopes of these, the many-jointed enveloping rock throws down yriad fragments, which in white streams streak the darker gneiss. The ll seems to be perpetually swathed in snow, and, as it dominates with rangely serrated ridges over the sun-forsaken valley of the Dionard, this mposite mountain, the loftiest peak of the oldest world in Britain, may aptly termed the Grizzly King.

Being a composite mountain, we are not entitled to say more of the form hich atmospheric sculpturing would confer upon the material of which is most largely composed, than that its western peak, with uniformly ep slopes on three sides and a rough precipice upon the other, warrants e conclusion that, at least with high-tilted strata, *acutely conoid forms* ould prevail.

We do not even in the isolated mountain of Stack, obtain conclusive formation on the point, for this pyramidal hill unquestionably owes form primarily to faults. One of these can be seen from Loch ore, running directly up the eastern gable; and it will be found upon the mmit, cutting the hill longitudinally in two, almost along its narrow lge; while its grandly-precipitous northern face,—than which nothing in e way of rock-belted hill-side can possibly be finer,—is evidently the ith flank of the fault which formed Loch Stack.

Though, from the encumbered state of the hills of this range, we learn tle of their sculpture-forms, still the limits and the nature of the cumbering rocks disclose something of their history.

The sadly-worn and shrivelled bulk of the first firmament sank beneath e waters. We now enquire how deep did it sink?—and did it descend rizontally, or turn upon an axis? as Norway is known to be doing at sent, and as there is good reason to believe is Scotland likewise.

The mode of swathing of the table-land, and mantling of the hills, may swer these questions.

The lower flats of the table-land were all covered up; bed after bed coarse-grained grits were showered down upon the bottom, till they ained a thickness which in Teallich attains an altitude of 3486 feet; l, judging from the continuence of the same dip westward, a prob-le thickness of over 6000; they welled up over the higher hunches till

they capped Fashven, but their thinned-out edges nowhere reache even to the foot of the great eastern chain.

An after denudation, and a still posterior mantling, renders the poin somewhat obsure,—but, *somewhere a little to the west of the foot of th mountain range*, would seem to have stretched the eastern shore-line o the Torridon Sea. By a bit of its western, its deposits hang on to th Eye Penninsula of Lewis;—denudation would seem a second time t have cleaned out the scoop of the Minch.*

But the pebbly deposits do not now lie parallel with the presen horizon floor; in Sutherland for the most part they dip some 5° to th E.S.E. There is evidence neither of fracture with elevation on th westward, or of fracture with depression to the eastward. The purel local evidence would indicate that Eastern Hebridia had turned upo the axis of its eastern shore, and in sinking beneath the waters ha "taken a header" to the west. It is much more probable howev that lateral pressure had depressed the trough of the Minch at centre, and that this had been succeeded by undue local elevatio One thing is evident, namely, that when the old land was ag elevated above the waters, burdened by the eastern shore-belt of t Torridon deposit, its great range of mountains had still no coverin and that these, with an altitude more elevated than their present, h for a second epoch to submit, and partially to succumb to t assaults of wasting rains and warring elements.

Were the *Torridon sandstones*,—the formation which had be laid down in this old ocean bed,—now presented to our conte plation in the unbroken and rectilinear bands in which they we originally deposited,—nay, were they even seen either in transver fissure, or longitudinal escarpment, it is questionable if anythi would be considered more tame, and scenically repulsive. What w do see of the formation, as the remaining fragments of a once vast d posit, is very different:—it is as enthralling as a spectacle of scen magnificence, as it is overwhelming to the intellect as an example stupendous denudation.

The bands of barred stone which are seen passing from north to sout across the terminal faces of each individual fragment of the form tion, stop abruptly on their shorn-off cliffs, to be taken up again at th self-same altitude by the face of the next fragment, standing as it do even miles apart. Nothing could vouch more imperatively for the miles of empty air having once been filled up with linking stone. appears as if a mighty ploughshare had been dragged from east west across the huge belt of rock, and had hurried all but a few fra ments into the waters.

*The Minch is in the direct line of the Antrim,—Shiant,—Farö, volcanic outburs It may be a fall-in.

CREST OF STACK POLLY.- CONGLOMERATE.

M. F. H. Del.

Carved out of a mass above all others formless and void, these fragments stand isolated,—fantastic beyond measure. Scenery hunters have been said to "*rave*" about the splintered pinnacles of Coruisk, but these monolithic hills of Coigach have ever struck the beholder dumb.*

Fashioned from a material as unvarying in its mass as clay, they confront one another, no two the same; differing so absolutely in their every feature, that as another and another is seen to separate itself from the line, wonder at the endless diversity of form usurps the place of admiration. (*See the sketch from Handa.*)

And when the nature of the chiseling is examined, that wonder culminates.

There are but two stages of the process;—the opening of rectilinear fissurings in the rock-wall, and the falling asunder into sand of the constituent granules.

That the ploughshare found a ready entrance is palpable; for a series of great transverse faults, with occasional uphevals and subsidences, rent the great belt of rock into isolated fragments; the looser and the softer portions of which have been swept into the ocean.

It would seem to be a common opinion that ice had been the agent of transport here; but the sea-cliff aspect of many of the rock-fronts, indicates wave-action.

The most isolated of these hills, that called Suilven or the "Sugar-loaf," is usually regarded as pre-eminent in peculiarity; but, as illustrating the modes of their sculpture, that is, the processes of degradation of the rock-mass itself, and indeed even for its general form, the rocky shaft called Stack Polly must take precedence.

Dr. Macculloch is of the same opinion, (he errs in calling it *Coul Beg* however.) He says "It is even more remarkable than Suilven, while its form is more elegant and versatile. In every view it is as graceful and majestic as it is singular; and like the other mountains of this extraordinary shore, it has every advantage that can arise from independence of position; rising a huge and solitary cone, from the high-land beneath, and lifting its dark precipice in unattended majesty to the clouds."

Certainty the most marked feature of these mountains of Torridon sandstone is the vastness and truly *mural* character of the precipices which girdle them, frequently upon several of their sides; this feature has been accounted for by Nicol, who writes,—"The beds have been vertically divided by a rude prismatic structure, and the projecting

* "The other side of Chaos," was the expression of one upon his return, *solemnised* an early morn's first inspection of them.

butresses resemble the fluted pillars of some gigantic Cathedral, carve and fretted by the genii of the rain and storm."

In the south-western ridge of Teallich and on Stack Polly, th endless diversity in form of the pinnacles into which a flat-bedded an sand-grained rock can be air-wasted, is a scarce less wonderful featur

The ridge of Stack Polly connects, if it can be called connecting two terminal massive bastions, square as if rule and angle had bee laid to them, and cleft as clean downward as if the Axe of Omnipoten had dealt the blow. The hill thus presents both features.

Its bastions stand as inaccessible to climber, as they seem regar less of winter blast and rending ice; the Bolts of Heaven alone cou affect them. But the ridge which stretches between, is actually beim blown away in sandy dust, by the wind. The more enduring portio have been left however in the form of spiracles; these are d posed not on the actual ridge alone, but protrude from both its slop standing erect or toppling; and they are of extreme tenuity. T hill in fact seems to bristle with divergent spikes; so that we forcibly reminded of the "fretful porcupine."

From a distance, however, and when merely the sky-line of the is thrown across a blaze of mid-day splendour, these pinnacles proj against the sky in a wondrously-felicitous similitude of human forms, or that of gnomes, intent upon some work of piling up, or teari down. Here, figures with out-stretched arms, direct; there, they be prone under heavy weights; and there again, seated, they seem to sto to chronicle the progress of the enterprise.

And, when the gloaming throws its glamour over the scene, and w approach to note more closely this strange fantasy of nature, and t shadows of evening close round us,—or the mantling nightcap of th mountains sinks from the zenith, heralding the sweep of the tempe these strange forms assume even more of the shape of man. Th great heart of Burns thrilled to the storm-scourged malefactor; b *there* was still humanity; and though these air-hewn images are on in its form, still the sensibilities are stirred, and our sympathi aroused, that anything, even though it be only in the *form* of ma should stand exposed, as do these, to the wild warfare of Atlantic ra ings. Here there is not even "looped and windowed raggedness," sheathe them from the blast;—naked as from the earth they came, mu they endure the pelting of every pitiless storm.

The wierd spectacle is now seen only in fitful glimpses;—as we gro among the spectral shapes, the *eerieness* is almost overpowerin Starting forth from out the whirling scud, now distant and now ne their shadows bulk gigantic on the gloom cast from the great squa

ROCK SCULPTURE ON STACK POLLY.

M. F. H. Del

ROCK SCULPTURE ON STACK POLLY.

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wers. Soaked by condensing fogs, and chilled by eddying blasts, we el as if it needed but one touch of those grim gaunt forms to root in their midst. (*See sketches of "Rock Sculpture on Stack Polly."*)

We are presented here with an illustration, perhaps the most striking Scotland, of the extreme diversity in external modelling which may, the different stages of their operation, result from the action of the me agents upon the same rock.

The opposing massive western dome of Suilven, and the ridge of ack Polly, are altogether as far apart, as types of rock sculpture, as n be conceived. But "even to this favour,"—in similar fashion, ast Suilven rot at last. It is the destiny of the everlasting mountains "change their shapes and flow from form to form," being mere hemeral embodiments of substances of many destinies,—a pabulum r the operation of unseen forces moving in ceaseless cycles.

Perchance it is through the very intensity of the impression of the *ite side of nature*, as here evidenced, that we are, by a kind of revul- n—when we consider it in relation to the register of time—over- wered with the sense of what has been called its *infinite side*;—"that e which yields no response to man's yearnings, and refuses to make elf plastic under even the strongest powers of emotion. For tside of and beyond man, aloof from his warm hopes and fears, his r and sorrow, his strivings and aspirations, there is the vast im- nsity of nature's forces, which pays him no homage, and yields him sympathy.

This aspect of nature is nowhere borne in upon man as in the esence of the great mountains, which seem so impassive and un- ngeable. Their strength and permanence so contrast with man, of r years and full of trouble—they are altogether heedless of his lings or his destiny. He may smile or weep, he may live or die; y care not. They are the same in all their on-goings, come what y to him. They respond to the sun-rises and the sunsets, but to his emotions. All the same they perform their mighty ctions, careless though no human eye should ever look on them,"— ing nothing, what strange story he may tell about their birth. lven will never bow his head to listen, nor Quinaig shake his sides nirth, or Coul Mohr shed a tear.

They keep their own secrets and drop no hint to him; his grand rdinations, his miserable squabblings, his pettiness and his pettish- s are to them less substantial than a wreath of vapour, and affect m not at all.

Considered as individual *monolithic hills*—and there are none in tland to which the term so fittingly applies—their character is t of an extended narrow cliff-faced ridge with gable ends.

They are occasionally precipitous upon every side.

Sketches have been given to show the changing features of gab and of flank. (*See "Gables," and "Flank of Suilven."*)

Sprinkled at somewhat irregular distances in straight line, at but short distance from the shore, they stand like a line of sentinels guard the land: and when we place ourselves, as at the Island Handa, in such a position as takes in an extended sweep of the lin we perceive that they must be but the fragments of a continuous b of escarpment, or perchance shore-cliff.

The western frontlet of Quinaig almost proves this. That cli face has nearly, but not entirely, been cut up, and still remains co tinuous as a far-extending rampart. The second sketch of Quina from the south, shows the diversity of outline which even one a the same hill can exhibit. Its north-eastern frontlet display precipice so intricate in detail and magnificent in form, as to be bey the powers of an ordinary pencil to depict. Of Coul Mohr, grandest and most versatile of the whole, it can only be said tha would take many wanderings before we could "tell of its h towers."

Perhaps their versatility is nowhere better seen than in Suilv when viewed from the north; whence the thinned off ridge has sumed a skyline which is closely imitative of that of the rough low rock,—as shown in the sketch.

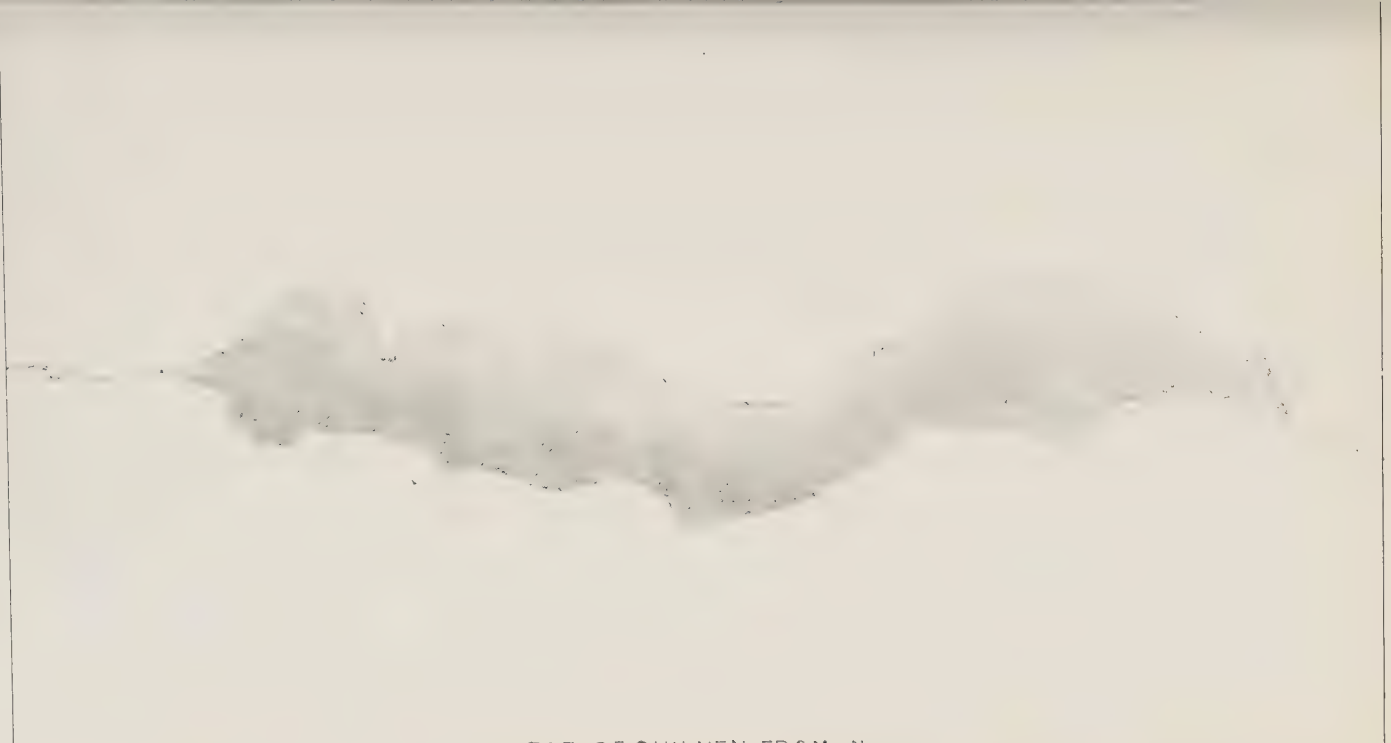
The isolation of these fantastic hills—their standing so far apart fr the high ground of the interior—the strange toning of their pur colour—and the marked contrast between their rectilinear courses a the fretwork roughness of the pediment upon which they stand, fo the *first element* of the *diversity of the scenery* of the hills of t district.

In order to be in a position to speak to the *period* when the gatewa were cut through the Torridon formation, and the pediment of old rock laid bare betwixt them, we must question the next formation.

What it cost to cut Suilven.

Reference has been made above to the finite side of nature, co sidered in relation to the register of time; and we have in this distri indeed in this formation, a more palpable record of the *first*, than any other part of Scotland. We have now to see if we can in a way, or in any degree, definitely consider it in its relation to t second,—the register of time.

The ridge of Stack Polly was selected as exhibiting the great amount of ruin; and, as the accuminating processes of decay have



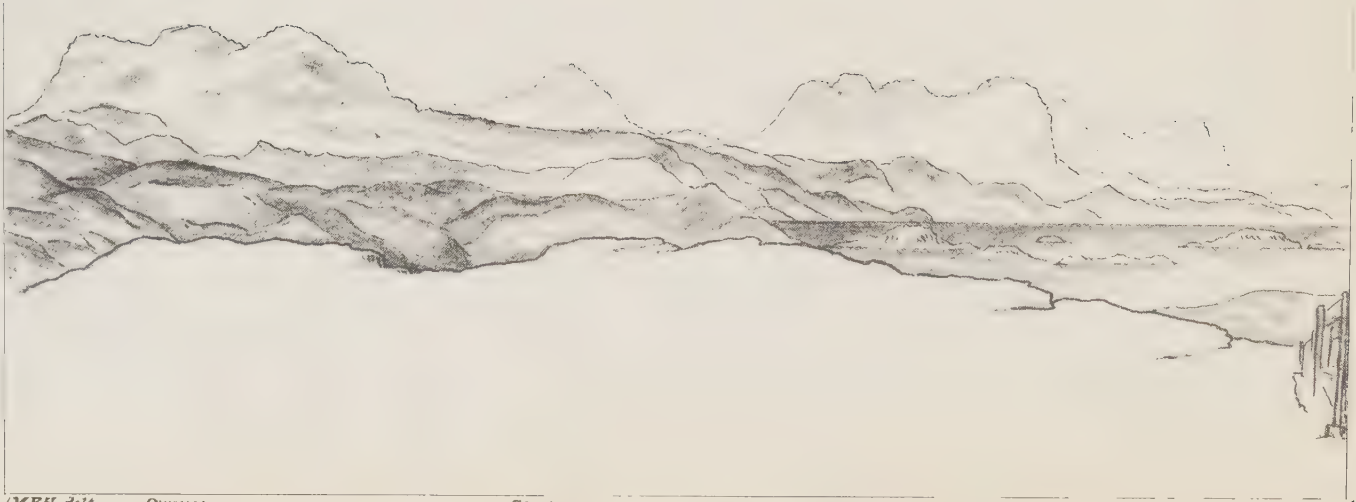
TOP OF SUILVEN FROM N

M F H Del

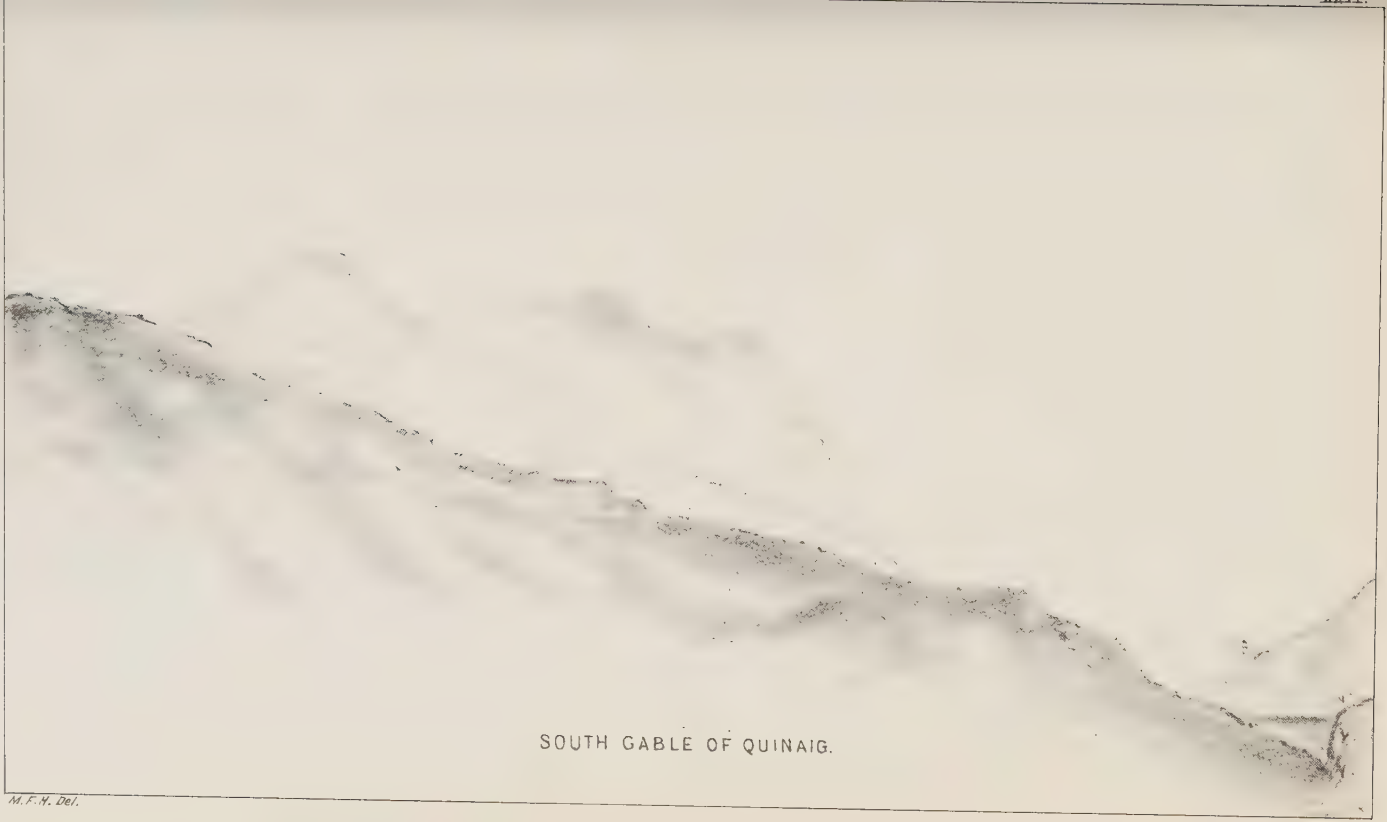
(M.F.H. delt.)

(W. IAGO fect.)

Western Escarpment of Quinaig.



Broken Escarpment of the Conglomerate, seen in Flank, ——from Handa.



SOUTH GABLE OF QUINAIG.

M.F.H. Del.

away its slopes, so that it is in that last stage of ruin, which exposes the increased surfaces of a ragged edge, disintegration is here advancing with abnormally rapid strides. Parts of the rock, as stated, are being blown away in sandy dust.

The contemplation of such a spectacle of rapid disintegration as is here presented, would lead one to conclude that the time requisite for cutting out the trenches which lie between,—or, to be precise, which *actually form* the Torridon hills,—need not have been by any means vast.

When the features of the formation as a whole, however, and the circumstances which obtain at this one spot, are considered;—in a word when the *mode* of sculpturing here and elsewhere is investigated, it will be found that the spectacle at Stack Polly is altogether an exceptional, and a very misleading one.

It was stated that the beds of this rock were divided by a "rude prismatic structure:" this is a marked feature of the formation. It is the falling together into one line of many faces of these prisms, which gives rise to that rectilinirity of the cliff-faces which is seen to prevail. Other faces falling together, produce more or less continuous transverse rents. Into these the peeling of disintegration throws the sand-grains which fall from the opposed surfaces; and out of these the wind, striking the flatly-extended line of cliff, sweeps them,—as it insinuates itself with concentrated force into the crevasses, like the separated fingers of an opened hand.

As the prismatoidal rents pass down through many beds, the rock is gradually cut up into a system of isolated rugged pillars. Striking instances of these are seen in Teallich, Coul Mohr, and most markedly in the "Old Man" of the Rhu Storr.

At Stack Polly the sides of the pillars have peeled off; until only needles, separated from one another by rents, widened into wind-tunnels, now remain.

The disintegration of a Conglomerate rock is accomplished by the loosening asunder of its component granules, through the soak of water,—very much more than through the per-oxidating effect of the air. The rounded and agglutinated granules had come through a worse trial as regards the attacks of the latter agent, when they rolled as a loose shingle, than they had to do when packed together as a mutually cohering mass.

The amount of action of solvent water upon a granular, that is an interstitially-porous mass, is in the direct ratio of its penetration. In film, that penetration is simply due to capillarity; under wind-pressure it becomes wedge-action. A sandstone wall may make a dry house if

the rain is merely streaming over it, in calm :—that rain streams dow the innerside of the wall when blown through in a storm; and tha the more, the heavier the gale.

Say that the penetration is an inch, with a wind-pressure of l pounds on the square foot, on the wall-precipice of Quinaig :—wha is the pressure, and what is the amount of this loosening penetratio at the top of one of the wind-funnels on Stack Polly's ridge?

One such funnel the writer ascended,—situated on its N.W. fac It was about five hundred and fifty feet in height; and the extent cliff-front, which in a northwest wind would direct the blast into a up this funnel, was about six hundred feet, at the base. The whol of this concentrated force of action, (which,—making a large allowanc for a great deal being thrown out of the funnel by its elasticity,—mu yet have approached the point of liquifaction of the air,) was thro upon the narrow neck which connects the summit with the ridge. Wh has it done there? Doubtless it formed that neck originally; but lat it may be said to have cut the neck in two. The exact date at wh the Cairn on the summit was erected, we could not ascertain; b that Cairn, now overthrown by the wind, has not been reached f seven years. And after all, the *one step* which was blown away, gra by grain, and the want of which renders the summit inaccessible, w little over a cubic-foot in bulk.

While a cubic-foot, in say twenty years, seems a most rapid destru tion, it has to be borne in mind, that elevated ridges of hills, which cat every wind, and which are so constantly steeped in mist, or envelope in condensing-cloud, are altogether differently circumstanced from th main bulk of rock which lies in comparatively sheltered trenches; a such spectacles of destruction as are to be seen upon Stack Poll however instructive in their way, are altogether misleading, in a co sideration of the time necessary for the removal *of the general mass* a formation.

It indubitably would be equally aside of sound arugment, maintain that those portions of this formation which have been r moved, were the softer; and that the remaining fragments were se evidently more enduring, because harder. The nature of the eve bedding, and the unvarying texture of the many layers of the roc in themselves form an ample contradiction to such a view.

The occurrence of east and west faults, either in the centres, along the lines of the trenches, entitle us on the other-hand to hol that the already-considered process of continuous widening of a crac and sweeping out of the resultant waste, might have been the fi step in the process of this trench-formation. That the succeeding ste

may have consisted in the rush of waters through the wall-sided chasm so formed;—in the establishment of a drainage system,—and in the continuous downward wash, and slip and slide, and flood-scour, which constitute the various steps, by means of which a rain-drop is the primal operator in the forming of a valley. And thus we might argue that it is through their *intermedicity between these faults* alone, that the the remaining fragments stand. But while holding that the ordinary processes of valley-formation, operating along lines of weakness, are sufficient to explain the isolated position of these residual masses, the preponderance of probability indicates another mode of channeling of the gaps which occur in the continuity of the formation. Indeed the level of the Hebridian pediment at east and west, is too perfect to lead us to believe that the scour of running water had much to do with the abstraction of the material which originally linked hill to hill.

The facies of those lines of rock-wall is altogether that of sea-cut cliff; so much so that we can scarce entertain any other explanation, than that an angry ocean had for long ages lashed in fury against their sides; and formed the basement-line out of, and over which they rose, sheer and inaccessible.

And in this consideration of the mode of waste of this formation, we cannot but pause as the spectacle which these isolated rock-islands must have presented, images itself forth upon the mental eye. No such spectacle does Britain anywhere now present:—much do we question if such is to be seen in the wide-world.

It is worth the seeing, and there is but one way of seeing it;—clearly, as if by open vision, has the writer often seen it;—he could even *picture it;* but it is indescribable. The Faröes shoot up their trappean cliffs from deep lanes of water, with a precipitancy so great as almost to close the land over-head, and eclipse the Zenith; but even their stepped rocks would appear altogether tame when compared with those of mountains standing isolated in the sea. St. Kilda is of the type: sprinkle the Ocean *with a group of such,*—gigantic in their bulk,—and then consider the picture.

Whether the land was dissevered by scouring rivers, or beating waves, matters little in a consideration of the amount of force, and of the time requisite for the work:—both are but modifications or outcomes of the same primal power. Deltas might establish the operation of one; sand-banks and shoals of the other; but the clean sweep of the after ice, has left neither:—so that calculations which we might have based upon either, are not within our reach.

We may cite the extreme apparent hardness of certain portions of the rock, as an offset against the loose grains of Stack Polly. Or point to the rolling boulders on the shore of Handa; the smooth external polish of which, equalling that of the surfaces of the imbedded nodules themselves, points to a durability which has, through long ages suffered no diminution. We simply find ourselves, with the data within our reach, unable to master the problem of the time, or the force called for to accomplish this great disrupting work. Fortunately, it has been approached from another starting-point; and a sister science has held out a helping hand. We have all agreed to go to the Sun as, of material objects, the one from which all force, as concerns our Globe, emanates.

Dr. Haughton, in a very remarkable paper lately published, (from which I extract, briefly, results only) lays down, that—The heat *received* by the Earth per annum, would melt an average thickness of ice over its whole surface of 80 feet. The mean annual *radiation* of heat *from the Earth*, is equivalent to melt a coating of ice 28·5 feet in thickness; so that we have 51·5 feet of ice representing heat, *not accounted for as heat*, (for the mean temperature of the Earth's surface is not being increased year by year).

This large balance of heat is expended,—

1st. By being converted into geological work, done by rainfall and rivers.

2nd. It is converted into chemical and vital work, done by vegetables and animals.

The mechanical or geological work done in crushing to fine powder a cubic foot of rock, was estimated from data taken from the stamps of Polberro Tin Mine. Each stamp weighs 600 lbs, and is lifted and falls through 9 inches, 45 times in one minute. Each stamp crushes 28 cwt. of tin-stuff in 24 hours. Hence the work done in crushing one cubic foot of rock is equal to 713·5 foot-tons.

The geological work done by rain and rivers, takes 3,090 years to crush and carry off to the sea, one cubic foot of surface rock. (One foot in depth evidently meant).

So far Haughton. Let us now apply this: taking a portion of the district under review, to do so.

Suilven stands in nearly the centre of a great denuded tract; it remains as a voucher for the ruin and removal of all that once connected it with Quinaig on the north, and Coul Mohr on the south. It was hewn out of a great flat sheet of the Conglomerate, in much the same way that there is reason to believe the Sphynx was hewn out of an isolated block of stone, in the Desert: from both, the sides were cut

nway, and the residual block fashioned very much each in its present mage. From Dr. Haughton's data, we can get at the amount of force necessary, and the time necessary to cut out Suilven; and then we can calculate the cost.

The depth of the formation is got at by drawing from the height of Quinaig, say 2650 feet, an air-line to the top of Coul Mohr, say 2,700; and abstracting the height of the Hebridian foot of Suilven, say 650 feet: leaving 2,000 feet of thickness, cut away. This, multiplied by 3,090 years for each foot, gives six million one hundred and eighty thousand years, for the time requisite for the full *geologic-work power* of the earth's share of sun-force to accomplish it in. That is for *the hiseling out*, but not *the building up* of the hill.

In laying our rule across the country to ascertain the amount of work for calculating the cost, we have to apply it, first as regards the *width* of the rock which had to be removed, in order that the tombstone might stand well isolated; and we find, that from the cliff-face of Quinaig, to the equally well-cleared off frontlet of Coul Mohr, is eight miles, (42,440 feet); that is the narrowest part. Next, for the *length*. As no other tombstone has been left to obscure the view, either in front or rear, the Conglomerates are clean gone, from the point where they dip under Canisp, to where a fault, apparently, has pitched them down out of the way, at Stoir. This is eleven miles, (58,080 feet).

42,440 × 58,080 × 2,000 = 4,889,830,400,000 cubic-feet,—or 181,105,829,629 cubic yards of Torridon, to be shunted out of the way. And this had to be done, not by dynamite, tossing a thousand or two of tons aside at once, but grain by grain; through the operation of a process which *used up* precisely the same amount of sun-energy as is consumed by the force employed in crushing by a stamp-mill.

What is the labour-value of this work?

In India and Australia, where the time-value of attendance on stamping mills is the lowest; and where experience has adapted the force of falling water in the most perfect and the most thrifty manner, the lowest cost of crushing a ton of rock (after it was quarried) is three shillings and seven-pence.

Each cubic-yard of the Torridon rock may be taken as weighing two tons. So the *money power* necessary for cutting out this one hill is £63,386,690,587. This may be regarded as the value of Suilven,—*scenically*: and it imparts some faint idea of the immensity of the forces of nature!

The *second element* of the diverse scenery is afforded by an almost

equally dissevered range which stands immediately behind and eastward of the sentinel-hills of Coigach.

The hills of this more easterly range, from the purity of their colour, and from the brilliancy of the light reflected from their peaks after rain, were declared by Pennant to consist of marble; but the material is quartzite.

Occasionally they stand isolated, blocking up at short space behind, the interspaces of the Torridon range; generally, however, the rock which composes them forms merely a cap to some portion of these elder-born hills.

We have already seen that when the old Hibridian land was depressed, and when the gravels and grits of the Torridon sandstones were deposited upon it, the eastern range of its hills still remained above water. But it was not so when the land again sank.

There is no peak, not even the loftiest of the range, which was not now overflowed.*

The shore-line of the new sea was not far distant from that of the older, though here again denudation does not permit of its being laid down with any pretension to accuracy. Two facts are patent,—the waters in which the sediments which were to form the new land were laid down, lay nearly altogether to the *eastward* of the previous; and these waters, with the coarse gravels and sand which settled in them, overlapped to an extent of over a mile westward, the shore-line of the Conglomerates.

The fact of, and the manner of this overlapping, renders it easy to fix the period when the great trenches of these conglomerates were channeled.

First, as to the manner of the overlapping. It is, at least for a long stretch in the northern portions of the junction,—in fact throughout all the Sutherland and Cromarty portion of it,—easily seen that the two formations are not conformable. The contrast of their colours makes this readily observable. The easterly dip of the Conglomerate averages 5°;—that of the upper formation, which is also easterly, averages 7°; while in its dip it swings more round to the south.

It is evident that there had been some amount of denudation of the outcrop of the Conglomerates, before the covering beds were laid down; it is also evident that now the great *general depression* of the land, or at least the *localisation of the sedimentation* was to the east; this is proved by the upward succession and continuance of these beds in that direction; while the higher dip of these to the east is strong ground for holding that the sinking land subsided to the *greatest*

* I cannot speak as to the Maiden, never having ascended it.

ertical extent to the westward, but was, upon re-elevation, restored o much the same horizontal level it had stood at when the table-land f the old gneiss was formed.*

The overlapping of the Conglomerates had to be upon their upper eds—but that overlap must perforce *have shown itself upon their lower eds also, if these had been trenched by any local denudation, previous to the dimentation of the newer rocks.*

This overlap is seen stretching westward over the slightly-denuded utcrop-beds of eastern Quinaig; it sweeps up the hill to an altitude f about 2300 feet, and to within a fourth of a mile of the peak; and s altitude upon an opposite peak might entitle the assumption that, ad it not been since denuded off, it would have appeared over- ving the summit itself of the hill. The opposing peak of Torridon andstone upon which it appears, is the more northerly and more levated of the twin summits of Coul Mohr. It is an outlying patch f quartzite which thus appears; but the main bulk of the rock reeps over the eastern bosom of the hill, into close proximity with ne outlier.

Thus then we see that the ocean of this new rock,—the snowy uartzite,—had extended westward, at least to the line of the summits f Quinaig and Coul Mohr, and had there welled upward to a present ltitude of over 2600 feet.

Had then the great trench-valleys which lie between the Torridon ills—as the two between Quinaig and Coul Mohr—existed *before* or *hen* the land was depressed, the waters would have rushed into nese gorges or channels of the island-hills, and *deposited in them* ne lowest beds of the quartzite.

But no particle of the quartzite has *there* been found;—it extends estward only on the hill tops;—it is there that the lowest, most ebbly beds are found. The denudation of the Torridon was quite rifling before the deposition of the quartzite. That quartzite there- ore was laid over it while the lower rock was still a continuous belt; nd that enormous transverse scooping of the Torridon, which resulted n the formation of those monolithic hills,—which according to

* There probably was a fault some miles to the west,—the Lewisian Land being ft, throughout the deposition of the quartzite, above water. Was it the fault which its-off Handa? It would be an easy explanation of the reversed dip of the Torridon ock—usually S.E. in Sutherland, N.W. in Torridon—to hold, than an axis of elevation un up the country along the line of reversal. It would be most satisfactory if this ould be found; unfortunately, although that line is in many places admirably exposed r investigation, there is evidence *along it* of neither folding, crushing, nor of fault. f course, in accordance with the requirements and dogmas of fire-side geology, there *ust be* one or other.

Macculloch, "have *no connection* with anything around them,"—but look "as if they had tumbled out of the clouds,"—took place in some comparatively recent time. Certainly more recent than the faults which have cut through both formations;—a time indeed when Conglomerate and Quartzite, and still more recent rocks, were trenched together.

So that here as elsewhere, "Nature's first step—like the patriarch of old—had been to bury her dead out of her sight. She hastens to conceal and hide the ruins she has made. Then after a time,—often a long, long time,—she again exhumes them, bids them as it were live anew, rise up and tell their story."

In the marked contrast afforded by the dead-white quartzite capping the purple grits, and in the full exposure of that contrast in the clean-cut transverse trenches, we have arrived at a *second* explanation of the striking scenery of the west.

For *the third*, neither eye nor foot has to stretch far; we have but to step a mile or so further inland,—passing over the debatable ground, the shore-line of the ancient Torridon Sea,—and note the strange contrasts which present themselves, where the snowy rock sweeps over and inwrapps the higher summits of the sombre Hebridian Hills.

There is here far from the same tranquil reposing of the one rock upon the other, that we found to obtain where it overlaid the Torridon. There was not here as there, anything like a gently-sloping platform for the sedimenting sand-grains to rest upon. The bottom was one of the most uneven imaginable; for the range of hills had, during two successive epochs, stood bared to the agencies of waste, and had been cut-up into sharp-featured, and, in some cases, into isolated peaks.

From the vast quantity of debris which has rolled down all the slopes of those hills which are capped by the quartzite, it is not easy to find spots where, either on the slopes or at the lower parts of the hill, the foundation-beds are disclosed; and so co-ordination of the several beds is well nigh impossible. Nor is it easy to pronounce where the faulting has let down a huge junk into a totally anomalous position. But from their great thickness in some localities along the strike, and thinness at others, there is every reason here to believe that the sands may have been in some spots deposited in pre-existent troughs.

The great hill of Arkle seems to have been cut out of such a sand-filled trough; if not so, the space between Fionaven and Stack must have been faulted down, before the more recent denudation carved out the hill.

Ascending Foinaven, which flanks it on the north, we do not, at a point immediately opposite to Arkle, reach the quartzite until we attain the height of about 2,500 feet. Upon Stack, which opposes it upon the south, we find the lowest pebbly beds of the formation at the height of 2,350 feet; while in Arkle there are beds (but whether the pebbly beds, cannot be ascertained) as low as 800 feet, resting upon a low hill of hornblendic gneiss. From off the southern portion of this low hill, they have been denuded, leaving a flat terrace, which slopes gently to the east, but precipitously to the south. This terrace when viewed from the swellings above the head of Loch Stack, has a most singular appearance; forcibly illustrating both ancient and recent denudation.

This central district of the range is typical as exemplifying outlier mappings of the quartzite.

Its more northerly stretch however, illustrates what may be regarded as the appearance normal to a hill-range, which is overlapped by a new formation. Northward of Foinaven, the linked chain of hornblendic hills is taken up by Cranstacach, then by Spionnaidh, while lower elevations stretch onward, to end the land in Kean-na-Bin.

Of these hills, the first-named are overlaid by a long sweep of quartzite, in a range of vertical precipices of over 100 feet in height,—the over-lying beds drooping gently eastward till they pass under the waters of Loch Erribol. From off the green hornblendic rock of the more northern, the quartzite has been denuded.

The continuous eastward slope of the sterile quartz formation has conferred the name of *Hill of Desolation* upon the middle height. No spot of earth could surpass it in sterility and deadness, it is typical of inertness and absence of motion. "All this barrenness, sterility, utter absence of life, is the result of the indestructibility of the quartz. It is dead, because the ordinary powers of nature cannot act upon it. It wants the higher organic life, because it endures too long as an inert inorganic mass."

Regarded from the west, again, as we pass down the lower Strath of Dionard, the appearance is altogether different; for the towering green rock, capped by the long stretch of white, is the very embodiment of a great ocean-billow, sweeping westward with its curling crest of foam. In Meal Maonich and Meall Meddin, the billow is heaving upwards, but the curling cap is gone.

The main bulk of the quartzite,—and this belongs to the highest member of the system,—lies in the vicinity of Ben More and Bræbag.

There is much greater thickness here. The unevenness of the bottom partly accounts for this; for the Hebridian rock had here been denuded down to an altitude of about 1,500 feet; only one small point indeed of such an altitude,—which is seen west of the Dhu-loch-More—appearing. But there is also here a much greater actual thickness of the formation.

The hills of this upper series bulk well as back grounds, from their tone of colour exalting the effect of those already noticed; but they cannot, apart from their gashed and riven cliffs, be said to be possessed of either grandeur or beauty. "Their cold, spectre-like aspect, when remote, is almost warm and living, compared to the bare icy sterility that reigns amid their glens and corries. The rocks smoothed and polished by ice-action, shine with dazzling whiteness. No flower or tree, scarce the hardiest lichen can find root or soil in crack or crevice. Rare patches of black moss—blacker from the white basin in which they rest,—a few detached stones, broken by the winter storms from the higher pinnacles, alone diversify the surface. There could scarce have been less life there when the snow nevé filled the upper corries, and the ice-river flowed down the Glens."

Still, here, just where something is wanting to break in upon the sameness of their interminable bands of white stone, that something appears. An interstitial band of grey limestone finds a most fitting place; here, presenting a craggy ivy-clad frontlet, there a stretch of verdant sward; here a chain of pellucid lakelets, and there again just that sufficient glimpse of the greenery of cultivation, which introduces the element of human sympathy into the scene. And here, yet again, to relieve the eye both from sameness of colouration and tameness of outline, there start up bosses of igneous-rock, and cleft face of fault,—intruded sheet, and great lime-swallow; churning the land into a tossed heap of fragments, so that this is the accepted summer-haunt of the querulous, the much affected battle-ground of the quarrelsome.

Had we to assign special forms to the hills of each of the foregoing formations, we would connect the conoid form with those of the Hebridian rock; the serrated ridge with aiguille peak would be assigned to the Torridon, and the long cliff-face escarpment to the Quartzite.

The forms assumed by the latter formation, however, depend much upon the underlying rock. When this consists of the Torridon sandstones, and the *lower* quartzite is under consideration, the definition of long cliff-face escarpment applies; because, from a certain similarity

both in the mode and size of the jointing of the two, and from the *underlying* rock giving way most, the amount of debris which results from the waste of each is much the same; and this debris having been equally thoroughly scoured off, clean-cleft cliff-faces, and hill-tops but thinly covered with fragments, generally appear.

But, with the *upper* quartzite, and the uneven bottom of the old gneiss, it is very different; the fractures of this upper-bed are very much more numerous and open; in many places the rock, nearly pure silica as it is, appears rotten, and is highly shattered and fragmentary. There is a northerly projecting spur of Foinaven, which has a sky-line like the backbone of a skeleton horse; while the south-westerly shoulder and slope of Bræbag is a mere heap of ruins.

There is something altogether extraordinary at first sight in the amount of looseness of the clean-cleft blocks which lie in enormous profusion over this rounded, but exceedingly steep slope. One might almost suppose that they had been sparsely imbedded in a calcareous cement, which, having been dissolved away, had let them light upon each other, in all positions of loose arrangement. Each one seems to be upon the move, so that the descent over them calls for a most attentive eye and an ever-agile ankle.

The extreme looseness of the stones upon hill slopes had often puzzled the writer. Upon hill tops, the constant drench and drain of water cleans out and sweeps off all small particles and binding clay; upon most rock-runs and "scridans," the surface-stones at least, have been chance-caught, as each was experimenting for itself upon the angle of rest. These are evident; but the cause of the looseness of stones upon *moderate* slopes, and in such positions as that on Bræbag, the writer only attained to the knowledge of, very recently. Mentally he saw it, or saw through it, a few years ago on the cliff-foot of Cranstacach; visually he *saw it operating* a year or two after, upon Am Binnian, in Perthshire.

Driving snow and sleet is forced, first from this side then from that, into every crevice of the loose-lying blocks. As these blocks have the warmth of the earth, a certain amount of the snow is melted. The water trickles into the crevices, and is held by capillary attraction in the narrow chinks between the stones, and in the close neighbourhood thereof. At night this water freezes;—expansion, irresistable expansion takes place; and every stone, at least of the superficial layer, is lifted upwards; settling, when the thaw ensues, gently down into an altogether-loosened poise.

So, precisely as the bird, by thrusting its bill through them,—or the dandy in "sprushing up his hair,"—so does old Mother-Earth

yearly plume herself,—shaking her stone-feathers loose. The only difference being that she chooses the winter-time to do it in, and the dead of night.

A strange feature of the scenery of this sterile formation remains to be noticed.

The closeness of the rents and fissures, especially of the superior member, has been adverted to; it was specially instanced in the loose blocks of Bræbag, and the stone-runs of Foinaven. But disintegration goes no further; that ultimate loosening of the cohesion bonds of the rock, which would result in shifting sands, is nowhere seen; and thus, grim and ghastly, like the dead bones of an older world, it protrudes above the surface.

It is the destiny, and it is the duty impressed upon every particle of matter on this globe zealously to prepare for a new service as soon as each earlier commission is performed; and, measured in the great cycle of revolving time, it is not long that any particle lingers in any one stay,—in the performance of any one function,—or as the special property of any one fabric;—for it is urgently called for by others. The wondrous machinery of nature is fashioned of materials which no one of its parts can ever claim as peculiarly or abidingly its own. The attrited nodules, for example, which went to form the eldest born conglomerates,—fall out of place, ever to rise higher and higher performing, with constantly diminished bulk, the self-same function, to younger and still younger rock.

Similarly rounded and worn *pebbles* of this quartzite formation have been recognized by Bonney in the conglomerates of Arran, and in the Bunter pebble-beds of Staffordshire; and the writer has fancied that they formed a part of the conglomerate of Heclabir in Orkney. But the *sandgrains themselves* are not set free,—as usually obtains in sand-grained rock.

That this is, and was such a rock is proved beyond doubt by the myriad worm-holes which pervade it. These may be seen in ascending Bræbag from Lynn, throughout the whole thickness of the lateral heave of the mountain,—over 1,500 feet.

At right-angles to, and through each bed, of less than two feet in thickness, do these plugged sand-pipes pass; sometimes proportionally as close as are the holes in a draw-plate. Silent witnesses,—beyond number numberless,—to the fact that the whole great hill was in its successive layers once tide-washed by the waters; and that its shifting grains then gave place, and yielded a ready passage to such teeming of existences as, in the life-history of our globe, has never been surpassed.

But these sand-grains yield no longer. They are now united by the dovetailing of partial inter-penetration, and by the cincture of silicious and ferruginous cements; and that so closely, that the rain-drop finds no chink for its wedge-edge, and nothing which it is potent to wrap out.

Neither have the *saline* waters prevailed, in effecting more.

"As the sands of the sea-shore for multitude." Of *what* sea-shore? Truly he would be far-travelled who could point to the *sea-shore* whereon there were no sands. No tropic,—no clime,—no country; unless it were an ice-fringed verge. Nature,—conservative in general principle, willing to submit only to gradual and slow change,—knows well her best breakwater, and spreads out her gently-sloping sandbanks to fringe the land, and cheat the billows of their might by that gentle yielding, or appearance of yielding, which turneth away wrath.

As for *country*, so for *formation*; silica prevails throughout. Our own country teaches us this, not less well than any. The Hebridian gneiss of the Long Island is fringed on the west from end to end with great tracts of loose sand-grains. At Sandwood and at Kearvaig, the Torridons show the same. The disintegrating quartz-bands of the Upper Gneiss have filled up grand harbours, and *made* the cockle-growing Kyles of Tongue and of Duirness; great cliffs of the Old Red lie grovelling in the Bay of Thurso; so also of Coal-measure shores; and the recent formation at Gruinard, whatever it be, has, as it blows about, given the name of *Sand* to the locality.

But it is not so of *this* formation. It is anomalous in its lethargy. The bond which unites its particles is indissoluble; and the sheeted slopes of Spinnu, plunge, unswaddled by any such fringe, into the deep dark waters of Loch Erribol;—for the rock is, in its very nature, *iron-bound*. So is it also that it endures, the highest land in the county; but, in *even-bedded and shapeless forms*,—for it is unhewn; and, with the chisels at present at the disposal of Nature, it is unhewable.

The effect of lime as a fertiliser is nowhere so strikingly apparent as where it occurs in but small amount; or in isolated spots among rocks which are destitute of any mineral containing it. In this district of Sutherland, highly siliceous rocks so prevail, that its effect as such, may be said to be exalted into its acting as a *populator*. Such has for long been its enduring, or rather it may be said, its *still-abiding* function,—from Erribol to Loch Kishorn. The clustered hamlets at Innisnadamph, Elphin, and Knockan, give evidence of local amplifications; while intermediately-disposed shepherds' houses form with these the connecting links of a far-extending belt of greenery.

Beyond or aside of this, the limestone has little effect upon th scenery; it has indeed little of its own that is visible.

Of that which is invisible, except to the mind's eye, it has much; an a wondrous scenery it must be,—judging from the glimpses of it whic we can obtain.

The traveller who passes along the road which, southward Knockan, skirts the foot of the great limestone cliff, must, after w weather, be delighted by the numerous gushing springs which di charge their sparkling waters, apparently from forth of the solid roc These, however, from their small size, can hardly prepare him for th spectacle of a rapid-running brook, issuing from beneath his ve feet, to whose sources and beginnings the perseverance even of Livingstone could never attain. On this side of the road it *was not* :— you rest upon the solid rock, which towers overhead. On that,—the flows the brook, ready formed; rushing with such ample and s swift flow, that you speculate whether even the agile trout could st its waters, and shoot into those dark abysses to learn the secrets their mysterious vaults.

There can be but little doubt that the faulting which occurs in c nection with the limestone throughout its whole range, suffices explain its hidden streams, its "sinks," and "swallows." The surfa waters,—finding their way into rents, which primarily were no m than breaches of continuity,—soon would dissolve the walls on eith side, and form free channels of escape.

To such an extent has this taken place eastward of Stronchrub that the whole formation is in a carious condition. Loch Maolock Cor catches the drainage of an extended district, but the point of t escape of its waters is for the most part undiscernable. That they escape, and that in no stinted flow, is vouched for by the "Boilin spring" which gushes from the south side of Ben na-creisag: and, the north side of the loch the secret is to a small extent declared, an a brief glimpse of their hidden workings is vouchsafed.

For short space the waters of a limpid stream quietly glide betwe softly-swarded banks, suddenly to be precipitated into the abysses of gaping chasm. The horrors of that yawning gulf seem only the mo horrible from the elastic softness of the green mantle which creeps the very verge of its treacherous lips.

Short shrift to him beneath whose incautious feet that verge crum bles; jagged projection, and alternately protruding buttress, wou unjoint him piecemeal, as he shot from the bright reflection of lim stone effulgence, through that grey-gloom of middle distance, to plun into a blackness of darkness, which looks solid in those far-off depth

But it is far from solid. The thunder of the ever-falling waters sends up a hollow boom which tells of oft-repeated plunges; and the tortured and disjointed surface, gaping ever and anon with inosculating rent, and trenches cinctured with treacherous sward, speak to the rottenness of the land. The firmest foot may well tremble; the stalwart stride, brings no safety to its possessor, for *it* will be the first to break the crust. Tread gently here, you are over a grave, and the firmament is "waning awa."

Göthe must have been in Scotland! He must have looked over that horrent verge; he must have imagined *his* body taking that crashing plunge,—or he never could have written "Abandon hope,—&c."

Could the passage be explored? for the waters come to daylight again, less than a mile to the north. We should like to try,—armed with a rope, a pair of miner's clamps, a bag of compressed air, and a pocket-full of condensed sunshine, in the form of magnesium wire. And we might, were it not for the treachery that is around, above, on either side, and below. What hidden horrors there must be in that 'middle passage," what scenes of gloomy grandeur, domes of blackness, and pitfalls of pitchy perdition!

Why go to the Mammoth Cave when we have a place like this in Scotland? There surely might be satiety with a tunnel a mile long! Could a pigeon be trained to prospect,—they are curious after holes! It were vain,—for the roof doubtless dips into the waters, with repeated flexure, and bars the way:—"*there is a path which no fowl knoweth, and the vulture's eye hath not seen.*"

The waters of this burrowing stream steal to light in the most covert manner, muddling themselves up with those of surface rills which have accommodated themselves to the "caved-in" trench of the subterranean channel. But there is just such-another darkness-loving rivulet, in the north of the county, which debouches in no such stealthy fashion; but which, from its raising its head just at the ocean's verge, as if it desired to render its tribute to the main with no insidious gliding, has produced a scene, to use Macculloch's words "alike extraordinary and impressive."

This is the cave of Smoo.

It is significant of its wonders that even the graphic writer above quoted has failed utterly in describing it; and, from the excuse which he offers, he seemed to have been conscious of his failure.

But even a greater than Macculloch would seem to have considered it beyond his powers. That he who wrote the wondrous descriptions of Coruisk and Staffa, should feel himself unable fittingly to grapple with Smoo is most significant; and we believe that by most who

thoroughly, and *in fitting circumstances* explore it, it will be regarded as the most wondrous scene ever beheld by them.

But the spectacle at Smoo is dependent to a very unusual degree upon circumstances ;—the circumstances here called for being an overflowing volume of water. We do not suppose that even Niagara would be much *as a cliff*, if its waters were dried up ; and certainly Smoo is reft of all its eerieness and gloom, and of much of its glamour also, when visited in drought.

It may have been considered that in our remarks on the scenery of Sutherland, we have made use too much of the penetrative eye of the geologist, in detailing *subterranean* pictures ; but *here* we must descend to a still lower depth,—nearer yet a step to the central core,—and consider much that is *subaqueous*. Little that is subaerial has Smoo to show ; but that little has a charm which contrasts most forcibly with, and enhances by a contrast of altogether-unrivalled abruptness, the pandemonial blackness of its other scenery.

In ancient days a rivulet has thrown its waters in spray from off the verge of a straight-lined limestone cliff; and through long ages has eaten back, at right angles to that verge,a wall-sided trench ; this has an inward depth of over four hundred yards, and an altitude of well nigh a hundred feet.

Those who wish to know the colour of pure Atlantic water may learn it, in the flooring of that chasm. Such cannot be seen in the English channel, or in the Pentland Firth ; for these are but the drains of the German Ocean,—the mud-polluted cesspool-sink of all Europe. It may be seen still purer to the west of Harris ; but that four hundred yards by fifty, is so glorious in its pellucid green that it sparkles gem-like,—even in similitude of a huge aquamarine laid down upon the land.

The southern land-floored end of this great trench is a *cul de sac* half-domed and roofed by a thin shelf of rock. The light which slumbers within that dome, once seen, is *felt*. The light—what there have of it—of all caves is fine ; that of this is surpassingly lovely. Poets would call it a *chastened* light. If by that, is meant that it resembles a character which, through the buffetings and disappointments of the world, shines with a softened sweetness, we partly understand the application ; and it would here be a fitting one. For chemists,—monsters, who are always insisting that "lovely visions are to yield their place to cold material laws"*—tell us that while the light which

* Beg pardon, Sir ; chemists and other naturalists only maintain that beauty will be appreciated all the more if its *causes* are understood. P.D.

Right, my boy ;—and so the *primal source* of these "causes" more nearly approached

s reflected from a smooth metallic surface shows but little of the colour special to the metal, from its being overpowered by the glare and glitter of polished reflection, the same light when reflected back and back again from two similar surfaces, gradually loses the false glare, and becomes subdued; shining ever more and more strongly with that tint which is of its own true and inner essence. And here it may be the case that what little light finds entrance is reflected over and over again, beaten back and back with repeated buffetings from the cold grey walls of the opposing sides of the chasm; so that all false glitter, and mere blaze being eliminated, it shines in its own true tints, and with "chastened" splendour. And truly if the buffetings of the world could only educe from the character such soft sweetness as that which hangs mistily in the outer cave of Smoo, one might willingly, after presenting the one cheek, turn and exclaim—"this is the other, now."

It is in such light, that the pillars and fallen masses of rock, draped in their lichen-grayness and fernery of green, are steeped,—upon *one* side of the Cave. Upon the *other* they are not steeped, but drenched in dews which come not from heaven, but from——well, from an opening which looks very like one of the gates to it.

This is not only the other side of the Cave, but it is very decidedly the other side of the picture also. Blackness is blacker than blackness itself, when there is white near it, or mixed up with it; this is the case in the west wall of Smoo Cave. From forth of a perforation like a cathedral-window, but black as night, there roll and gush volumes of white misty vapour,—flung like snow-drift upon the dark night;—issuing unceasingly, as if the store of energy which propelled them was infinite; and backed within the gloom, by the crash and thunder of falling waters.

In order to ascertain the cause of all this turmoil, it is necessary to procure a boat; for a strangely-boiling chaldron intervenes in front of and below the only apparent entrance to the gulf within. That this is, apparently only, the sole entrance, is evident, as the boiling pool in front,(whose waters hold a direct course to those of the wall-sided geo), must have an underground connection with those heard thundering within the gulf of darkness.

The subaqueous scenery here consists of some perforation, situated immediately beneath the great steam-hole which is visible above, and from which it is separated by an arch of rock. This arch is in part submerged. The perforation as a whole has thus much of the form and appearance of a great mark of exclamation—!—of which the dot is subaqueous, the dash subterraneous. It would seem as if nature, in order

to emphasize the strangeness of her working, had breached the pa
tition wall, with a rent bearing the similitude of the sign of wonde

On being launched into the inner chaldron, the first sensation exper
enced is "that you are about to fall down into some abyss; though th
least consideration is sufficient to show that this is impossible in a boat.
The second is a desire to ascertain in some degree where you are; bein
dimly conscious of the fact that it is not exactly water which is beneat
you, nor exactly air which is above. What little light there is, wher
by you ascertain this, emanates from an apparently glowing sha
which seemingly radiates moonbeams; but which is ever emittin
angry corruscations; corruscations which, smiting you in the face, y
discover to be water. As the rapidly-dilating pupil admits more ligh
the shaft resolves itself into a lashing and waving cateract, throw
from some mysterious source, which seems mantled by gloomy skies.

The dome-shaped roof of this hidden hollow of the land, is nearl
hundred feet above its floor, and the falling waters are precipitat
from a height of eighty-five, through an orifice, which in flood th
nearly fill. Some sixteen feet from the bottom, they strike upo
shelf, from which they are dashed in fan-shaped jets;—these, crossi
at every angle, become pulverised into water-dust; while the smitt
waters of the gulf itself, lashed into hissing foam, surge in whirli
waves against the sides of the chaldron, from which, beaten ba
tumultously, they again converge, clashing against those of the ou
ward flow, and conspiring, as it were, to give meaning to the expressio
"a hell of waters."

Such is what is gradually *felt* to be what is going on around; fo
from the violent dashing of the water from every side, the ey
is nearly useless,—the ear is stunned, and the feeling is puzzled, every
thing around being as wet as we are ourselves. For, aside of th
utter contempt which Smoo evinces for Macintosh, the strange an
perfectly-palpable mixture, or it may be called *emulsion* of air an
water around, is potent in discovering the weak joints of the armour
and finding its way to the skin.

There is a second small opening in the roof of this cavern, through
which light might enter, if it could; which in such circumstances it
cannot. The opacity of fogs to light is well known, and the water
dust within, is very much more opaque than fog; indeed it will be
seen, by anyone who stands above, and who regards the vapour gushing
from the gash, to reflect the light almost as snowily as do the mam
milated rolls of a fleecy cloud.

But Smoo's wonders are not ended. Nature has written *another* mark
of exclamation on that wall which is directly opposed to the first.

Nay, more; as if to *invite* to further search, the writing upon this wall has been lifted clearer to the light; so that the dot of the point of exclamation is, on this side, partly above water. The rib of solid rock, which gave trouble in placing the boat in the cavern, in the first case, is here lifted overhead, and there is a continuous water-floor from where we are, to whatever may be within. But, though the arch of rock is, upon this western side of the cave, curved *overhead*, it is so only if the head assume a position lowlier than its wont. We must lie down in the bottom of the boat. There need be no hesitancy, on account of the quantity of foam which has overlapped its gunwale, inasmuch as we are thoroughly wet already; a fact which excitement alone prevents us from recognising.

This second water-floored cavern, though very much larger than the first, is more of the nature of a crevice. There is depth of water for the boat to advance for some short distance, when it is quitted; and the washed-out rent is traced westward and upward,—the explorer having to walk deliberately up the bed of a rapidly-running stream. He is suddenly arrested by three things. First, by a black pool which occupies the full width of the passage. Next by a cascade which falls from the south, into that pool from some height,—this also occupies its full width. And lastly, by the continuance of the rent or passage, or cave,—whichever it be regarded,—at right angles to its previous course; and that in so diminished a height as to cause him to hesitate as to advancing further, even supposing he could surmount obstacles one and two. As to the pool,—it is just as ugly a looking hole as could be seen; an oar finds no bottom, even when sent below the water with a mighty swish. As to the cascade,—condense Lodore in height,—not in width,—and apply to it all the adjectives which a once well-known poet fantastically picked out of the dictionary to irritate still more that fussy stream, and you would still feel a want in describing this. As to the continuance of the cave which is still the bed of the burn,—it is one of those pipes, several of which the writer has noted as being connected with dogs; dogs which have gone through them, and come out minus their hair; and up which pipers have gone, and never come out at all. All of which,* the reader is not expected to believe, for the best of all reasons, namely, that the writer does not believe one word of it himself.

And yet after all, this pipe is better than the most of these, for it has got another end. In wading up the bed of the burn, many lumps of peat are to be seen. And what is there worthy of regard in a lump of peat, lying in the bed of a burn? Nothing in general; but the

* Dogs and Pipers

nearest spot where the peat-bog comes to this place is more than tw miles distant; and these pieces of peat have therefore done what th spectator has neither done or probably could do;—they have *explore the pipe.*

Little or nothing of what has been described will be seen by thos who visit Smoo Cave when its stream is not in flood. It were as un reasonable to expect it,—nay, it were more unreasonable to expec it, than it would be to expect to behold a fair scene from a moun tain top, at dead of night. For, whereas light only *discloses* th scene from the mountain top, the rush of waters into the cupola cave of Smoo, both *purveys* the light, which most fittnigly dis closes the scene,—dragged down in its own mass and radiating there from like the jet from a water-sheathed electric-lamp,—but it is als itself the source and power of all that which is most worthy of bein seen.

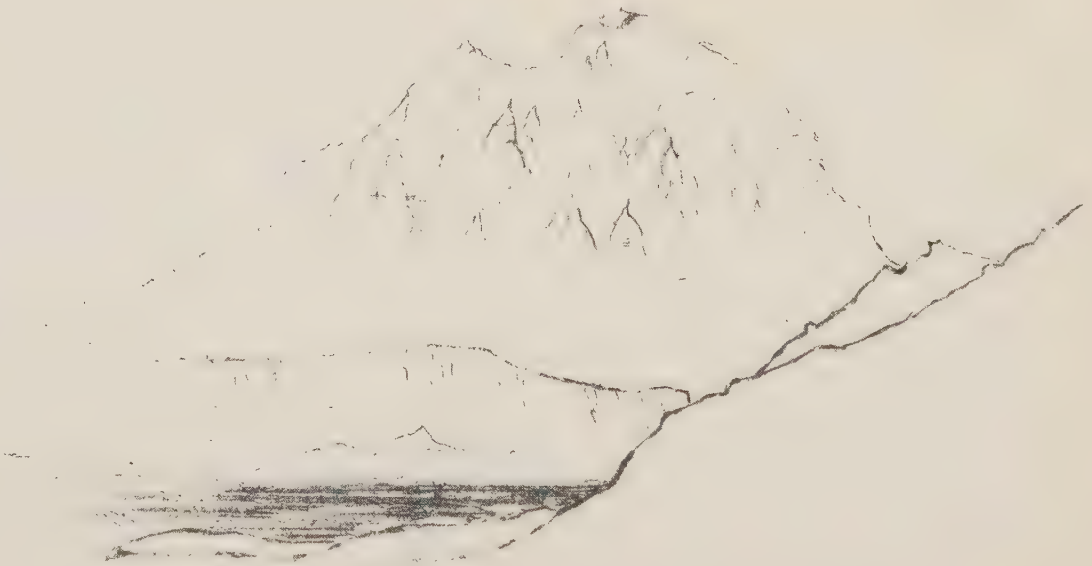
After it has been visited while in full force, by all means should i be revisited, during what may be termed its calm; especially if t configuration and mode of formation of the Cave is to be considere The judicious employment of magnesian wire will then educe *a spe tacle*, wondrously grand in its way. But to see it *first* in such a manner would most assuredly rob it of that glamour-might, which lies em bosomed in its light-dispensing waterspout; and present it shorn of a that tremendous clash and conflict, which makes its grim depths suc a "naughty place to swim in."

As the mode of formation of this strange chasm is closely connecte with geologic cataclasm, its consideration is deferred until the lime stone of the district is spoken of.

The writer would just say in parting with it, that he considers tha Cave of Smoo as being *beyond measure* the most wierd and wonderfu sight which he ever beheld; and he understood his companion, who has seen very much more of the world's strange sights than he has, to be of the same opinion.

The series of very diverse, and on the whole markedly schistose rocks, which go to form what has been called the Upper Gneiss, cannot be said to be characterised by any special type of hill.

The first I notice is the somewhat dome-shaped Ben Hope. It is only a dome when viewed from the eastward, for it is precipitous to the west. This hill is formed of a very loose and fissile mica-slate. Where exposed in cliff-escarpment it is disintegrated, in consequence of the openess of its foliation. Runlets of water have cut gashes in its bold western front, and the fall of the loose foliæ of



BEN HOPE. BUTTRESSED MICA-SLATE.

M.F.H. Del

the stone has accuminated the upper parts of each intervening prismatioidal mass of rock; so that we are now presented with perhaps the finest illustration in Scotland of *a buttressed hill.* But here they are the buttresses of disintegration, formed out of weakness; though like other buttresses, they also tell of internal weakness. (*See sketch of Ben Hope.*)

Another hill of this formation I note, for the consideration of those who do not believe that falling-waters are potent to cut out valleys. It is Ben Hee. It has a hideous shape,—very like a Whale. That portion which performs the function of the neck,may be described as a stepped precipice. Upon examining this it will be found that the stream, which flows south-eastward, has been gradually running away with the material of the hill, and eating backward into it; undermining it at the same time, by having got a hold of an unusually shaley bed.

The superincumbent mass of rock is slipping into the corry; rending itself in the so doing, by a series of huge cracks; these, extending downwards, as each slice slips a bit lower and still lower, gape with hideous width,—a trap for snow, sheep, or the incautious foot which may be too inquisitive upon their crumbling lips.

The hills of Old Red Breccia which clustre round Tongue are of rounded outline and devoid of beauty; though, where cut into cliffs, as at Cnoc Veecdan, the forms are both grotesque and bold.

It would have sufficed to remark of the outliers, which remain as isolated remnants of a somewhat superior bed of this formation, that they have the ordinary heavy rounded form of Old Red Sandstone hills, had it not been that one of these forms "an honourable exception," and is beautiful exceedingly. This is Ben Griam Beg. Its big brother is not an honourable exception, for it is typically lumpish; yet there *it* stands, the parentage and the upbringing unquestionably the same; and so near do they stand to one another, that one cannot conjecture wherein lay the difference in their sculpturing, which opposed the noble form of the one hill, to the altogether tame and ignoble outline of the other. (*See sketch of Ben Griam Beg.*)

Griam Beg, being somewhat of a crag-and-tail hill, would be held by some to vouch for scour from the west.

Still one class of rocks, and but one hill of that class remains to be noticed,—the "volcanic" Ben Loyal.—(Laoghal).

Thinking of Scotland's Hills, we ever return to *this* as the Queen of All. For gracefulness, chasteness, versatility, and nobility of form, it stands pre-eminent.

It is more difficult to name *the King*; but we incline to a hill in Perthshire, when viewed from the shoulder of Ben Yoss; a hill strange enough, of the same name,—Ben Laogh.

Ben Loyal is, more than any other hill in Scotland, an *Aiguille* hill. Not that there are aiguilles *upon* it, but it is *aiguille-formed* itself. Not a single projecting horn, like Teneriffe, Yan Mayen, or Scuir na Caiche; it would not be so fine by many times if it were; but it has many peaks, is in fact set round with peaks.

What can be finer than its northern face,—round about whose feet the loving birches cling, creeping closely up and up, till they find it is no use attempting more; for it is unapproachable! What more independent and grandly assertive than its western horns,—which seem as if they had shot up through separate throats, and had been congealed in the very heavens;—like sun-flames of hydrogen, photographed while yet they flash. What more enticingly mysterious than those corries and gulfs of blue haze, which separate peak from peak! And then the *setting*:—all the accessories are fine; the wavy outlines of the lesser hills which cluster to form a middle-distance, and the winding bay with its stretches of sand, banded with bright-green waters.

And then the mystery of *its being*. Not of its birth. Wonderful to relate, geologists have not quarrelled about that: they are ready enough to do so about granites generally; but about this granite they have not. Our own belief is that it has proved too beautiful to quarrel about.

Not of its birth; not of its death; that has not come yet, and we at once exclaim "Oh, Queen! live for ever!" But of its having, with these sharp serrated outlines, resisted the scour and sweep of the devastaters which ground down the table-land around it, and left the two Griams standing,—just as it were to show what they had done elsewhere.

Its hardness and unalterability would enable it to endure; but not to preserve such peaks, sharpened like tongues of fire.

Sooth to say, while contemplating this hill, one's energies are so absorbed in admiration, that there is no place for geognostic speculation concerning it;—and it is moreover hard to have to anatomise the thing we love. Murchison draws it as eruptive, turning up upon its flanks the adjacent rocks; nowhere was the writer able to perceive any evidence of such disturbance. What did appear evident regarding it, is connected with *cold*, not *heat*. It is impossible to believe that the great ice-sheet which by some is held to have scoured over

(M.F.H delt)

(W.IAGO. ft)

Ben Loyal. Syenite

ll Scotland, ever topped these summits, and left such rough and ıgged lines behind it.

In presence of those high angles and serrated ridges, and in presence f the lower rounded Stomino to lee of it, and above all in presence of ıe Skerry and Stack standing with similarly accuminated shaft above ıe waters, it is much to be suspected that far less of the grinding and earing down of the waste midlands of Sutherland was the work of e sliding in solid mass over the land, than of the wash of waters, ıd the scour of ice *floating among the shallows*, and pushed over the sser heights.

That Stomino is glaciated is at once conceded ; but its glaciation is ı old story ; for its sweeping curvatures pass under the scanty bands Old Red Conglomerate which, with cliffy fringes, hang on to its ırts :—though it is not contested that *recent* glaciation may not have ıd much to do with the late scalping of its bared head,—a glaciation hich very possibly was cradled among the opposing summits of oyal.

It is not easy to say what is the angle of the peaks of Loyal ; they ould seem to be about the steepest, not to be *cliffs*, in Scotland. The inometer does not much help here ; because on the spot, one has ıough to do to hold on, and not go to the bottom in a single slide ; ıd when measured from a distance, on account of the over-lapping several slopes, too low a result is got.

The camera is still worse. Justice without mercy, defines its por- ıiture performance ; and in "performing" among the hills, it is dly wanting even in the first. The lowering of angles, and taming wn of distant hills so much complained of regarding it, is, as regards e former, probably due partly to the overlapping mentioned, and partly our own *hankering after the extreme*, and so, picking out the steep ts for storing in our memory ; while the camera on the other hand, ry probably placed in the position which suits the whole hill, reshortens the acuter angles. The *taming down*, again, which is in- ıbitable, is probably due to this, that the lens of a camera has not e same *penetrative power* as the human eye, nor has it any power ıatever in *resolving* aerial perspective.

While the penetrative power of an "object glass" is an actual defect, though a most useful defect,—the penetrative power of the human e depends upon an extra adjustment, or set of adjustments of such ɔndrous mechanism that it is very doubtful if any human mechanist uld ever produce it. This he could do certainly neither in the space, d still less, so as to operate in the time necessary for the working of e adjustments, that the Great Mechanist has.

The "*penetration*" of a lens is a *fixed defect*,—being the name adopte to express its possessing a limited zone within which there is a nea approximation to perfection, though no one absolutely perfect focus the glass of greatest penetration being that which has a comparativel wide space of partial perfection.

The penetration of the eye is a *moveable perfection*; the limits c which extend from the seeing a fly upon the point of one's nose, to th counting of the stars in the Pleiades.

In taking photographs of scenery, therefore, when the lens is bes focused to a certain distance, all the others must be more or less out o focus; and the steep angles of distant hills are merged into on another, and softened down by blurring.

In transmitting a picture to the retina which volition has commis sioned it to record, the experienced eye does not focus, for more tha the briefest fraction of time, any one part of the scene, but wande over the whole, focussing near and far alternately with marvello rapidity. The nerve all the time imprinting every perfectly focuss point upon the optic memory, which retains each and all sufficient long for a perfect picture to stand forth. If the eye be focussed upo one point without moving, or *thus* travelling over the whole lengt and breadth of the view, all the rest of the picture is out of focu and blurred; and the side objects are hardly recognisable.

Aerial perspective—which John Phillip delighted to talk about, bu in which Arthur Perrigal apparently does not believe,—would appear to be largely due to the presence of dust in the air; for after rain i is hardly perceptible. As the far-off is then brought so near tha tints blende, there is no such perspective at all; and the pleasing softening effect, and that graduation of indistinctness which alike teach of distance, are, in the cleansed atmosphere, nearly altogether gone.

It would appear, therefore, that it is not distance which "lends enchantment to the view,"—but *dust*; and, indeed, it is difficult to understand how *distance* could lend enchantment to anything which is either pleasant or pretty; or dust either, for that matter.

Photographic lenses have as yet made very little progress at resolv- ing that which is behind the dust; and cross-lights mystify them en- tirely: and here it is that the eye has its great advantage; for it *can* focus through that cobaltic-veil which the beams have flung across the picture through yonder opening in the hills; and read the wrinkles in those sun-lit crags, even through that blaze of evening glory.

XII.—*Action of Organic Acids on Minerals.*

By Prof. H. Carrington Bolton.

CHEMISTS have long employed the commoner organic acids, especially acetic, oxalic, tartaric, and citric acids in mineral analysis, but with few exceptions they have overlooked the application of these acids to the decomposition of minerals. Acetic acid has been used to separate minerals from their matrix of calcite; Karsten (*Archiv. of Min.* XXII, 572) and Sterry Hunt have used it in the proximate analyses of mixtures of calcite, dolomite, and magnesite; calamine and willemite are sometimes distinguished by the gelatinization of the former with the same acid; Dr. J. Lawrence Smith (*Am. J. Sci.*, [2] XX, 244) has noticed the solubility of anglesite in ammonium citrate; W. B. and R. E. Rogers (*Am. J. Sci.*, 1848) have made experiments on the solubility of minerals in water containing carbonic anhydride; but there is no record of any systematic investigation of the action of organic acids on minerals with a view to the determination of species.

The following research was suggested by the difficulty of transporting liquid mineral acids on mineralogical journeys, and the need of a substitute in solid form. A few preliminary tests showed that tartaric and citric acids possess far greater power to decompose minerals than is commonly imagined, and demonstrated the desirability of extended study. Accordingly we selected and prepared for treatment, by the methods to be described, 225 specimens of minerals of whose purity and authenticity there was no doubt; these represent 200 species, their names are given in the accompanying table. For convenience these minerals may be divided into five groups, viz.:—I, *Carbonate;* II, *Sulphides, Arsenides,* &c.; III, *Oxides;* IV, *Silicates;* V, *Sundry Minerals,*—including phosphates, sulphates, arseniates, native metals, &c.

Reagents Employed.

The organic acids employed in this research were chiefly citric, tartaric, and oxalic; a few tests were also made with malic, formic, acetic, benzoic, pyrogallic, and picric acids. Of the solid acids the solutions used were saturated in the cold; citric acid being the strongest in its action was more exhaustively studied than the others.

The behaviour of the minerals with these acids was studied in a simpl manner; the finely pulverized specimens, freed from gangue, were treate in test-tubes with the reagents both cold and boiling. In certain case the gases disengaged were examined by test papers; and the filtrates wit appropriate reagents, whenever decomposition was not otherwise evident

Having observed that a strong solution of citric acid decomposes (*a*) sodium nitrate, (*b*) potassium iodide, and (*c*) ammonium fluoride,—settin free nitric acid, hydriodic acid, and hydrofluoric acid respectively, we ap plied these reactions to the decomposition of those minerals which resis the action of citric acid alone. We will briefly describe these reactions.

(*a*) When solid sodium,—potassium—or ammonium nitrate is adde to a boiling solution of citric acid (also tartaric and oxalic acids), o reaching a certain degree of concentration nitric acid is set free, whic immediately reacts upon the organic acid, liberating carbonic anhydrid and nitric oxide. If we admit the formation of oxalic acid, the reacti may possibly proceed thus :—

$$11\ H_3C_6H_5O_7 + 16\ KNO_3 = 8\ K_2HC_6H_5O_7 + 3\ H_2C_2O_4 + 17\ H_2O + 12\ CO_2 + 8\ N_2O_2$$

This mixture of reagents, which for convenience we shall designate t "nitrocitric mixture," proved to be a very powerful oxidizing solvent, a is shown in column I of the accompanying table.

Potassium nitrite decomposes citric acid in a similar manner,—th action beginning in the cold, and proceeding with energy.

(*b*) The well known facility with which even the weakest acids de compose potassium iodide, and the instability of hydriodic acid, makes th mixture of the solid salt with citric acid a very strong solvent of severa classes of minerals. We call it for convenience the "iodo-citric mixture."

(*c*). When ammonium-fluoride is added in solid form to a concentrate solution of citric acid, and heated, a mixture is obtained which attacks silicates with considerable power. The tests are of course made in pla tinum vessels. Partial decomposition is ascertained by testing for fluorid of silicon with a moistened rod. Since, however, we have carried on thi research largely with a view to *field-work*, we have examined only a few minerals with this mixture, and we omit these reactions in the table.

Behaviour of Carbonates.

All the natural carbonates examined dissolve with effervescence in cold or hot solutions of the organic acids named above.

Citrates being in general more soluble than tartrates and oxalates, citri acid attacks the minerals more strongly. Oxalic acid, however, yield precipitates, some of which are characteristic of the bases contained in the minerals; thus calcite is decomposed with formation of white pul

erulent calcium oxalate, which appears amorphous under the microscope; itherite yields beautifully feathered crystals of barium oxalate; siderite ves a pale yellow granular ferrous-oxalate, appearing under the micro- ope in the form of minute prisms, having a basal termination; and russite yields a heavy white precipitate of lead oxalate.

Acetic acid acts energetically; in fact glacial acetic acid does not tack calcium carbonate even on boiling; but decomposition begins at ice on adding one fourth part of water. Formic acid acts similarly, and elds with cerussite a white, lustrous, crystalline deposit of lead formate.

Since all the carbonates are decomposed by citric acid alone, we did ot examine their behaviour with the nitro-citric and iodo-citric mixtures.

Behaviour of Sulphides, Arsenides, etc.

Natural sulphides are very unequally decomposed by citric and other ganic acids. Of the 35 species examined, five are attacked by citric id alone in the cold, with liberation of sulphuretted hydrogen, and five e attacked on boiling the solution.

All the remainder are rapidly decomposed by heating with the nitro- ric mixture, except realgar, orpiment, cinnabar, molybdenite and prous- e; of these the first three yield to the iodo-citric mixture, but olybdenite and proustite completely resist these reagents.

The decomposition of the natural sulphides by the nitro-citric mixture, ords a very interesting reaction; taking pyrites for example, the ution obtained contains ferric sulphate, and hydro-potassium citrate, ile both nitric oxide and carbonic anhydride are abundantly evolved, nsequently the reaction may possibly proceed as in the following uation :—

$$FeS_2 + 26\,KNO_3 + 12\,H_3C_6H_5O_7 = 2\,Fe_2(SO_4)_3 + 2\,K_2SO_4 + 11\,K_2HC_6H_5O_7 + 15\,H_2O + 13\,N_2O_2 + 6\,CO_2$$

Oxalic acid mixed with potassium-nitrate acts similarly, and the re- tion may be expressed thus :—

$$3\,FeS_2 + 32KNO_3 + 29\,H_2C_2O_4 = 3\,Fe_2(SO_4)_3 + 3\,K_2SO_4 + 26\,KHC_2O_4 + 16\,H_2O + 16\,N_2O_2 + 6\,CO_2$$

Certain sulphides treated with these reagents behave in such a way as furnish additional means for their determination. Thus pyrrhotite and nite are decomposed by citric acid alone, while their kindred com- unds, pyrite and chalcopyrite (as well as chalcoite) are not attacked.

Since galenite is readily attacked and argentite is not, citric acid may used to detect a mixture of the former with the latter. Pyrargyrite decomposed by the nitro-citric mixture, while proustite wholly resists. hen galentite is heated with the iodo-citric mixture, the mineral is

completely decomposed,—sulphuretted hydrogen being evolved, and yello lustrous flakes of plumbic iodide are formed; this characteristic pr cipitate also forms when bournonite is treated with the same reagents.

The most surprising result, however, is the decomposition of cinnab by the iodo-citric mixture; this mineral is attacked even in the cold, an on heating the reaction proceeds with violence; on cooling the soluti deposits scarlet crystals of mercuric iodide.

When cinnabar is heated with oxalic acid and potassium iodide, t action is even more energetic than with citric acid.

Sulphur is attacked by the nitro-citric mixture with difficulty, sulphu acid being found in the solution.

The most easily decomposable sulphide seems to be alabandite, which strongly attacked by citric acid alone in the cold. The reactions of t selenides, tellurides, arsenides, etc., are indicated with sufficient fulne in the table,

Behaviour of Oxides.

This group includes such refractory minerals as corundum, rutile, siterite, quartz, and others, which naturally resist these methods of atta A few oxides are more or less perfectly decomposed, as shown in t table; the decomposition of the manganese oxides is very complete, a is accompanied with oxidation of the organic acid used. The addition sodium nitrate does not greatly increase the energy of the solvent, respects oxides, except in the case of uraninite, which dissolves complete

The iodo-citric mixture applied to oxides, affords no especially notat results.

Behaviour of Silicates.

In its action on silicates, citric acid differs from hydrochloric more power than in kind; those silicates which are decomposed by the miner acid, with or without the formation of a jelly, are also attacked by t organic acid. Of the 76 species examined, 21 are decomposed in the col 14 on heating with citric acid, 12 are partially attacked by the iodo-citr mixture, and 29 resist these methods of attack; the names are given the table. The most easily decomposed are the hydrous silicates of t Zeolite group.

Tartaric acid acts much like citric acid, as respects the silicates; b oxalic acid is less powerful. By treating silicates in platinum vess with a strong hot solution of citric acid, to which ammonium fluoride added, many of them dissolve very easily.

Behaviour of Sundry Minerals.

Under this head are grouped 38 minerals, whose behaviour is as vari as their composition. They include fluorides, phosphates, sulphat

ungstates, columbates, etc., the reactions of which are shown in the ble. We observe that all the phosphates are quite readily decomposed y citric acid alone; the fluorides are not attacked; of the tungstates olframite is slightly attacked by citric acid, hübnerite yields to the itro-citric mixture, and scheelite resists all the reagents. Gypsum ems to be somewhat more soluble in solution of citric acid than in water, t the sulphates of the other alkaline earths are insoluble. Wulfenite d crocoite are strongly attacked on boiling with citric acid. The native etals, silver, mercury, copper, arsenic, antimony, and bismuth, dissolve ith more or less facility in the nitro-citric mixture; the energetic solvent- wer of this reagent is further shown by the fact that it also dissolves ad and tin.

Summary of Results.

The accompanying table, to which we have frequently referred, sum- arises the results obtained by the application of these reagents to two ndred minerals. From this it appears that citric acid has a power of composing minerals little short of that possessed by hydrochloric acid, d this difference in degree evidently gives the organic acid an advantage er the mineral acid in the determination of species. Many of the actions are characteristic, yet we do not regard the table as a scheme determining minerals.

That this table is entirely free from errors we dare not claim; without fuller investigation than time allowed, it is, in certain cases, difficult to certain whether a mineral is merely attacked (one or more constituents ing partially removed by the solvent), or whether it is truly *decomposed.*

Application to Field Work.

The advantages of these methods in the examination of minerals and ks *in the field* are evident. Many geologists and mineralogists add to ir outfit for blowpipe work, a glass bottle of hydrocloric acid, carried a protecting wooden case, for the purpose of testing carbonates; but withstanding great care, the fragile glass often gives rise to unhappy idents. To avoid such inconveniences, we propose to substitute for the id acid, the solid citric acid, which can be readily carried in a strong teboard box, and dissolved in water obtained in the field, when required use. The facility with which potassium nitrate (or nitrite) is omposed by citric acid, makes it possible to carry nitric acid also prac- lly in a solid form; and the addition of solid potassium-iodide to this of *dry reagents* for *wet analysis,* greatly increases the means of study- the chemical characters of minerals in the field.

Hydro-potassium sulphate,—furnishing sulphuric acid in a solid form— already been proposed by E. Jannettaz (*Compte Rendu,* 1874).

The writer has tested in the field the methods above described, applyi them to the more common minerals with success. For the purpose working with solutions, a nest of test tubes (12 c.m. long) in a cylindri pasteboard case is found convenient; the innermost test tube may be us to hold pulverized citric acid. In the absence of test tubes, the writ finds the hollow palm of his hand a convenient and portable apparat for testing carbonates by their effervescence.

Application to Geological Phenomena.

The disintegration and erosion as well as the consolidation of rocks h been attributed in part to the chemical action of various solvents, amo which carbonated waters play an important rôle; if, however, we a permitted to reason by analogy, it appears probable that many chang imperfectly understood by geologists, may be explained by referring th to the action of the organic acids of the soil. If citric, tartaric, and ox acids are able to decompose minerals, rapidly and completely in the ha of the chemist, may not humic, geic, crenic, apocrenic, and other acid humus, in the lapse of long periods of time, accomplish much in the integration of rock-material on the surface of the earth?

The very existence in the soil of compounds of ulmic (?), humic, cre and apocrenic acids, with ammonia, soda, potassa, lime, magne alumina, iron, and manganese, is *proof* that these organic acids ex considerable influence. This is also shown by the existence of miner of which organic acids form component parts;—such as whewell thierschite, succinite, mellite, pigotite, etc.; as well as the occurrence limonites, containing 12·5 to 15· per cent of humic acid (Sterry Hu Geol. Canada, 1863, 510); and of acid hydrocarbons, containing the defined bodies, geoceric, georetinic, and butyro-limnodic acids.

Paul Thénard has remarked the extraordinary power of azo-humic a to dissolve silica (*Compte Rendu* LXX, 1412,); Bischof, Mülder, Her mann, Detmer, Seuft, and many others, have recorded observations on t geological action of the acids of humus; these notices are widely scatter throughout Journal literature; and, since we began these researches in t laboratory, our friend Alexis A. Julien, of Columbia College School Mines, New York, has collated all papers bearing on this subject, and h recently published a review of them, together with the results of origin study, under the title "Geological Action of the Humus Acids." Th will be found in the Proceedings of the *Am. Assoc. Adv. Science*, vol. 2 1879 (80).

TABLE SHOWING THE BEHAVIOUR OF CERTAIN MINERALS WITH CITRIC ACID ALONE, AND WITH REAGENTS.

I.

DECOMPOSED (IN FINE POWDER) BY A SATURATED SOLUTION OF CITRIC ACID.

1. IN THE COLD.

A. *Without evolution of Gas.*	B. *With liberation of CO_2.*	C. *With liberation of H_2S.*	D. *With separation of SiO_2.*
Clausthalite	Calcite !	Stibnite	Wollastonite
Leucopyrite	Dolomite*	Galenite	Rhodonite !
Atacamite	Gurhofite !	Alabandite !	Chrysolite
Brucite	Ankerite*	Sphalerite	Willemite ! ‡
Gummite	Rhodochrosite*	Pyrrhotite	Nephelite
Pyromorphite*	Smithsonite *		Lapis lazuli
Mimetite	Aragonite !		Chondrodite
Triphylite	Witherite !		Pectolite !‡
Triplite	Strontianite !		Laumontite !‡
Vivianite !	Barytocalcite !		Chrysocolla !
Libethenite !	Cerussite !		Calamine !‡
Olivenite !	Malachite !		Apophyllite
Pseudomalachite	Azurite*		Thomsonite !
Wavellite			Natrolite !‡
Pharmacosiderite !			Mesolite !
Torbernite			Analcite
Autunite			Chabazite
Flexite !			Herschelite ‡
Cryptomorphite !			Stilbite
Anglesite			Deweylite
Prochantite !			Prochlorite

2. ON BOILING.

E. *Without evolution of Gas.*	F. *With liberation of CO_2.*	G. *With liberation of H_2S.*	H. *With separation of SiO_2.*
Cuprite !	Hausmannite †	Bornite	Tephroite ‡
Zincite	Pyrolusite !†	Jamesonite*	Ilvaite
Malaconite	Manganite†	Bournonite*	Phlogopite*
Roethite*	Psilomelane !†	Boulangerite	Datolite !†
Simonite*	Wad !†	Kermesite	Prehnite*
Titanite (?)	Magnesite !		Heulandite
Apatite*	Siderite !		Serpentine
Wolframite*			Chrysotile
Wulfenite			Retinalite
Trocoite			Bastite
Gypsum*			Genthite
			Gieseckite*
			Jeffersite
			Masonite*
and those in A.	*and those in B.*	*and those in C.*	*and those in D.*

II.

DISSOLVED BY BOILING WITH CITRIC ACID WITH THE ADDITION OF:—

I. *Sodium nitrate.*		K. *Potassium iodide.*	
Silver	Cobaltite !	Realgar*	Pyrope
Mercury	Ullmannite !	Orpiment*	Colophonite
Copper	Marcasite !	Cinnabar !	Epidote
Arsenic	Arsenopyrite !	Hematite*	
Antimony	Nagyagite	Menaccanite*	
Bismuth	Covellite !	Washingtonite*	*and most of those in A, B, C, D, E, F, G, H, and I.*
Sulphur *	Berthierite !	Magnetite*	
Bismuthinite	Pyrargyrite	Franklinite	
Domeykite !	Tetrahedrite !	Braunite	
Argentite	Tennantite !	Enstatite	
Hessite	Stephanite	Paulite	
Chalcocite !	Polybasite !	Augite	
Tiemannite !	Enargite !	Spodumene*	
Millerite !	Uraninite !	Hornblende*	
Niccolite !	Hübnerite	Actinolite*	
Pyrite !		Pargasite*	
Chalcopyrite !		Olivine	
Linnæite	*and those in C. and G.*	Almandite	
Smaltite !			

III.

L. MINERALS NOT DECOMPOSED BY THE ABOVE REAGENTS.

Graphite	Hyalite	Wernerite	Titanite
Molybdenite	Diopside	Leucite	Staurolite
Proustite	Petalite	Anorthite	Bowenite
Fluorite	Asbestus	Labradorite	Talc
Cryolite	Beryl	Oligoclase	Kaolin
Corundum	Zircon	Albite	Ripidolite
Spinel	Vesuvianite	Orthoclase	Columbite
Chromite	Zoisite	Tourmaline	Samarskite
Chrysoberyl	Iolite	Andalusite	Scheelite
Cassiterite	Biotite	Fibrolite	Barite
Rutile	Muscovite	Kyanite	Celestite
Quartz	Lepidolite	Topaz	Anhydrite

Completely decomposed or dissolved. * Feebly attacked. † The CO_2 evolved is derived from the Citric Acid. ‡ Gelatinizes.

N.B.—The gases evolved are to be examined with acetate of lead test-paper, the solutions with appropriate reagents.

XIII.—*On Substances which may prove to be New Minerals.*

By Professor Heddle.

Part Third.

Tyreeite.

MY notice of this must be considered preliminary in every way.

The discovery of "the beautiful carnelian marble of Tyree" has been in a late paper credited to Dr. Walker.

For some years after its discovery, it was used, or attempted to be used for mantle-pieces, and other internal decoration.

Partly on account of the minuteness of its pattern unfitting it for this purpose, and partly on account of the small quantity sent into the market, it, however, seems never to have found its way into general favour.

We find Dr. Macculloch lamenting the wasteful method of working adopted in the quarry,—the wholesale shattering of its mass by the excessive use of "Mines."

As the contrast of colour presented by its several ingredients is both striking, pleasing, and unique, the employment of it for inlaying, for letter weights, and similar purposes, undoubtedly would be now general, could it again be got.

The quarry, however, would seem to be both exhausted and ruined, and for many years not even a "hand-specimen" has been procured for cabinets.

The general mass of the marble is of an impure white very fine grain, and it has a greasy lustre. Profusely sprinkled throughout this, there occur rude crystals of *Sahlite* of the size of grains of corn. An analysis of these has been published by me in a paper laid before the Royal Society of Edinburgh. They are of a lively-green colour, singularly banded with white lines; and were, when of pale colour, at one time regarded as *corundum*. The "carnelian" tinge which characterises the rock is not uniformly diffused throughout it, but stains it, as it were, in blotches; more rarely in bands; while it sometimes is more intense around or in contact with the imbedded crystals of sahlite.

Very rarely minute highly lustrous crystals of brown *sphene*, with rounded faces, are to be seen; and still more rarely masses an inch or two in size of watery-blue *malacolite*, or of rich dark-green *augite*. The fringes of the mass rarely show *graphite* flakes, and granules of *pyrrhotite*.

The manner in which the red colouring matter is segregated, led me to examine the rock in section;—and the failure of the microscope in revealing the nature or source of the colouration, called for analysis.

A number of ordinary specimens were dissolved in weak acid, and left undissolved a brick-red powder. From the very intense tinctorial power of this, from its appearance, and its total want of crystalline structure, I was led to suppose it to be new;—but the very minute quantity obtained rendered it impossible to determine this.

To the kindness of the clergyman of the island I am indebted for collecting at the spot the quantity which has enabled me to determine the little that I have done regarding it.

About one and a half hundred-weight of the rock were dissolved in hydrochloric acid, diluted with water to the extent of showing only the feeblest effervescence. Sixteen gallons of hydrochloric acid were required.

There were obtained about 30 pounds of crystals of *sahlite*; about one-eighth of an ounce of crystals of *scapolite*; perhaps half that amount of *sphene*; and some ounces of a red mud, evidently very mixed in substance.

It was found that by suspending this last in a large quantity of water the larger part of its bulk separated pretty rapidly as a dull-brown cream, consisting apparently of minute scales of talc; while the whole of the red pigment with much of the talc remained in suspension; adhering to the water with great pertinacity.

As the only mode of crudely separating these last, a series of suspensions and decantations in a large number of stoppered jars, was carried on for the space of more than a year. At the end of this, about three ounces of an impure, and half-an-ounce of an *apparently* pure product were obtained.

Operating afresh upon the purest produce, there was ultimately obtained 1·913 grammes of a powder which did not seem to be capable of being further purified by such a process.

This powder, when examined by the microscope, shewed no trace of fibrous structure;—the repeated agitations would unquestionably, however, have almost entirely destroyed such, had it ever existed. This powder was of a deep brick-red colour, and of very intense tinctorial power. Its extreme state of division precluded the employment of all methods of ascertaining its specific gravity.

When placed in strong sulphuric acid it was found that, of the 1·913 grammes, ·785 were dissolved, leaving 1·128 insoluble.

This last, when fused with Fresenius' flux, yielded, on ·65 grammes—

Silica	68·461
Alumina	no trace.
Ferrous Oxide	3·468
Manganous Oxide	·153
Lime	2·326
Magnesia	19·076
Water	6·85
	100·334

being probably an impure *talc*.

The portion soluble in acid, yielded :—

Alumina	8·227
Ferric Oxide	38·22
Ferrous Oxide	3·158
Manganous Oxide	·394
Lime	2·211
Magnesia	29·936
Phosphoric Acid	4·713
Water	12·466
Silica	1·019
	100·344

The qualitative analysis showed minute traces of two metals which I ould not determine ; one of these came out at the stage when Uranium ould have ; but tests for that metal in no way confirmed its presence.

The red portion was totally soluble in hydrochloric acid.

I know not what to make of this substance.

In the first place the total absence of alumina and ferric oxide in the rst analysis, with their large quantity in the second, indicates a perfect paration.

A chemical consideration charges us to pronounce it a mixture ;—the osphoric acid covering so small an amount of the bases. It cannot be an *hreous* mixture, for such could not exist in primative marbles, along with ich reduction-products as *graphite* and *pyrrhotite* : while again the nsentaniousness of its suspension as a whole, contraindicates a mixture. am fain to leave it in the hands of those who enjoy operating upon undred-weights and obtaining grammes,—after splashing with water for ears.

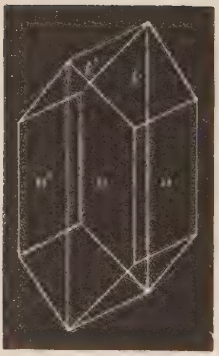
XIV.—*On Crystallized Olivine from Slag.*

By Dr. Charles O. Trechmann.

I have recently measured one of the crystals of the slag described by by Mr. A. E. Arnold, in vol. III, p. 114 of the Magazine.

Observed forms :—

Brooke and Miller. Mineralogy, 1852.	Naumann. Elemente de Min.
$a=100$	$T=\infty P\breve{\infty}$
$n=120$	$n=\infty P$
$k=101$	$k=2P\breve{\infty}$



Angles (normals)	Measured Trechmann.	Fayalite Miller.	Olivine
a : n ..	658 9′ ..	65° 12′ ..	65° 1
n : n′ ..	49° 42′ ..	49° 36′ ..	49° 58′
k : k′ ..	98° 32′ ..	98° 22′ ..	99° 7′

The angles are therefore almost identical with those derived by Miller (*Trans. Phil. Soc., Cambridge, III; Brooke and Miller, Mineralogy*, 1852. *p.* 319) from crystals found in refinery cinder, and the slags of copper furnaces, &c,—having the composition of Fayalite, *viz.*—2 FeO, SiO_2.

Making allowance for imperfection of the particular crystal measured, they seem to be intermediate between those of olivine and fayalite

Reviews and Notices.

itting of the physico-mathematical section of the Royal Academy of Sciences, Berlin, October 18th, 1880. *Rammelsberg.*

Artificial Gay-Lussit.

)BLIQUE crystals, consisting of one molecule of soda carbonate, one molecule of calcic carbonate, and five molecules of water, are ound in nature. Bauer showed 50 years ago, that this compound ystallized from a solution of sodic carbonate, at a temperature near that freezing. It does not, however, appear to be known that this double rbonate is produced in considerable quantity in the manufacture of dic lyes. These crystals, more or less impure and discoloured, are eposited at a temperature of about 40° in the vessels containing crude da lye. Smaller white crystals are formed in the towers in which rbonate dioxide is passed through the lyes, for the conversion of caustic to commercial soda.

Dr. Arzrum has made a crystallographic and optical examination of ese crystals occurring—

I. In the carbonized lye.

II. In the clear crude soda lye.

They belong to the oblique system.

$$a : b : c = 1{\cdot}4918 : 1 : 1{\cdot}4471.$$
$$\beta = 78{\cdot}46.$$

I. The type of these crystals is determined by the fairly equal velopment of faces $\bar{1}12$, 011 110: the faces 001 occur very seldom, id then always as slight truncations of the edges 011, $0\bar{1}1$. Faces of e first three forms are of equal lustre.

II. The predominant forms are 110, 011, 001 :—the faces of the last e frequently quite small, those of $\bar{1}12$ always so. The faces of 110 are aracteristically striated parallel to the edges of 110, 011, and $\bar{1}12$: the sal plane 001 is generally unstriated.

The percentage composition of the compound $(Na_2CO_3 + CaCO_3) + 5Aq$ 33·8 $CaCO_3$, 35·8 Na_2CO_3, 30·4 H_2O; while the purest crystals yielded 2·2, 34·2, 35·1, per cent of sodic carbonate. Not only do most of the ystals, the under parts of which are grey, yield a residue containing

silica, when treated with acids, but the solution so obtained gives with ammonia a gelatinous precipitate of alumina and lime, free from phosphates.

Loss of soda in the process of manufacture has long been recognised and this loss, due to formation of insoluble compounds, is proportional to the quantity of ash in the coal used. As this ash is mostly silica, alumina, and lime, silicates of alumina, lime, and soda must be formed in the furnace, and remain in the residues. Scheurer-Kestner considers the residues are richer in soda the greater the quantity of lime used in the manufacture, and attributes this to the formation of calcic sodic carbonate. The actual existence of this compound in the soda lyes is now proved.

T. W. D.

On the optical characters of the plagioclase felspars.—(MAX SCHUSTER)—*Min. a. Petr. Mitth. G. Tschermak. Vol.* III. *p.* 117.—This paper contains an exhaustive examination of the optical behaviour of the triclinic felspars—albite, oligoclase, andesite, labradorite, bytown and anorthite. The author, starting with Tschermak's theory that all the plagioclase felspars are mixtures of the two isomorphous felspars *albite* and *anorthite* (soda and lime felspars respectively), has investigated them for the purpose of discovering whether this theory is borne out by their optical characteristics; and concludes that "the soda-lime felspars form, with respect to their optical properties, a series similiar to that of all their other properties, and every mixture, consisting of definite proportions of the ultimate terms, has corresponding optical properties which approach either those of albite or of anorthite, according to the proportion of these constituents."

It follows from this proposition, that, given the optical behaviour of any plagioclase felspar, its chemical composition can be at once ascertained therefrom. The character upon which the author mainly relies is the angle, which the direction of maximum extinction, in plane polarised light, forms with the planes P. and M. (001 and 010). The relations between these angles and the chemical compositions of the various felspars (in terms of molecules of albite and anorthite) are exhibited in a diagram, and from the curves thus obtained the author deduces the following equations.

Let x be the percentage of molecules of anorthite present, and y the inclination of the direction of extinction, above referred to, expressed in degrees. Then $y = a + bx + cx_2 + dx_3$, where a, b, c, and d are constants. When y is the angle between the direction of extinction and P, the equation becomes,

$$y - 5 - 0{\cdot}1752x + 0{\cdot}001457x_2 - 0{\cdot}00003905x_3.$$

nereas when y is referred to M it becomes

$$y = 20 - 0{\cdot}5062x - 0{\cdot}008121x_2 + 0{\cdot}00007483x_3.$$

It is thus possible, given x to find y or *vice versa*, and thus the chemical mposition of any plagioclase felspar is determinable from its optical haviour; it is merely necessary to procure cleavage plates or sections rallel to P and M, to determine in them the direction of extinction, and being thus known, to calculate from it and from the above equations e percentage of albite and anorthite which it contains.

The author finally concludes that his observations prove the truth of chermak's theory, and also confirm the view of Senarmont, that the tical characters of a composite salt are variable, and approximate to ose of its predominating constituent.

H. L.

Mineralogical Observations.—*On the crystallographic and optical operties of Piedmontite*—(H. Laspeyres,) *Zeitsch. f. Kryst, un. Min. P. oth, vol.* IV, 5. *p.* 435,—The author devotes the present paper to an amination of the physical properties of the Piedmontite (Manganiferous idote) from St. Marcel, the chemical composition of which he has eviously communicated in vol. III., p. 525 of the *Zeitschrift* for 1879.

The conclusions he arrives at are:—

Piedmontite is a true epidite.

Its crystallographic and optical characters approach very closely to those of pistacite, excepting only the absorption of light, which is, generally speaking, complementary to that exhibited by pistacite.

Crystallographic characters—From a number of determinations the thor deduces the following axial relations for piedmontite:

$$a : b : c = 1{\cdot}6100 : 1 : 1{\cdot}8326 \quad . \quad \beta = 64°39'.$$

The prismatic crystals are bounded by the planes $\frac{1}{2}P\infty(\bar{1}02)$, $\infty P\infty(100)$, nich predominate; and oP (001), less extensively developed. All the anes are rounded and striated by oscillatory combinations, oP being the noothest and the most brilliant.

Optical characters—In a section of piedmontite, cut perpendicularly to e axis of symmetry, and in which the two cleavages form an angle of ° 46′, the angle, which one of the axes of elasticity, lying in the tuse angle between the crystallographic axes *a* and *c*, makes with the inoaxis *a* is

32° 47′ for the Lithium flame
32°2′ for the Sodium flame.

The second axis of elasticity therefore makes with the vertical axis *c* a angle of

7° 26′ for the Lithium flame.
6° 41′ for the Sodium flame.

and it lies in the acute angle between the crystallographic axes *a*, and *c*, at least for light rays of low refrangibility. The dispersion is thus unusually strong, the difference between the lithium and sodium flame amounting to 0°45′.

Pleo-chroism.—A section perpendicular to the axis of maximum elasticity [a] is dark-bluish red in ordinary daylight, and shews the maximum amount of absorption of light. In polarised light, this color is decomposed into a dark amethyst, for vibrations parallel to the axis of medium elasticity [b]; and a dark blood-red, parallel to the axis of minimum elastity [c].

The section perpendicular to [b] is of a bright orange-red in day-light and shows the least absorption of light. In polarised light parallel to [c]the section shews the above-named dark bluish-red colour; and, parallel to [a], bright orange.

The section perpendicular to [c] is dark yellowish red in ordinary day-light, with medium absorption. In polarised light parallel to [a] it appears bright orange, and parallel to [b] dark amethyst.

Moreover the directions of the "axes of absorption" (*i. e.* the directions in which the differences of colour attain a maximum) do not coincide with the axes of elasticity, except in the case of the axis of symmetry; and in the plane of symmetry the axes of absorption are perpendicular to each other, and form with the axes of elasticity an angle of about 20°.

Piedmontite is positively birefringent, the angle between the optic axes, and the index of refraction being both very great.

With respect to the twinning of piedmontite, the twins are always polysynthetic and lamellar, analogous to those of the plagioclase felspars; the twin plane being mostly $\infty P\infty$ (100).

H. L.